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Geology of an Area around Rottenstone and Dobbin Lakes

Part of NTS Area 74A

by C. F. Gilboy

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Precambrian Geology Sector

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Foreword

This report is published by the Saskatchewan Geological Survey as one of a series of reports resulting from a four-year program of geoscience surveys under the terms of the Canada-Saskatchewan Agreement on Mineral Exploration and Development in Northern Saskatchewan. This program is supported by funds provided by the Federal Departments of Energy, Mines and Resources (25 percent) and Regional Economic Expansion (25 percent) as well as by the Province of Saskatchewan (50 percent).

L. S. Beck
Director
Saskatchewan Geological Survey
September, 1981.

Abstract

The area described is underlain by Precambrian rocks of the Wollaston, Rottenstone and La Ronge Domains, each bounded by northeasterly trending zones of cataclasis.

The Wollaston Domain comprises Archean granitic basement overlain by Aphebian metasediments in which a well-defined structural succession has been recognized. The Rottenstone Domain is made up of intensely migmatized supracrustal rocks injected by early (metamorphosed) igneous rocks, later (little metamorphosed) granitoids of the Wathaman Batholith and finally diabase. The La Ronge Domain comprises unmigmatized pelitic metasediments injected by the Hickson Lake Batholith.

All rocks in the area were affected by two main regional thermotectonic events. The first of these events produced a gneissic foliation and/or schistosity and was accompanied by widespread anatexis, particularly in the Rottenstone Domain, under medium and high grades of metamorphism.

The second event generated the regional, northeasterly trending, tight to isoclinal, non-cylindrical upright folds; medium and high grade metamorphic conditions prevailed. Granodioritic and monzogranitic rocks of the Wathaman and Hickson Lake Batholiths were emplaced towards the end of this second event. Subsequent tectonism produced the Needle Falls and Paull River Shear Zones. A third thermotectonic event produced rare conjugate folds in the Wollaston Domain and mica growth under medium grade metamorphic conditions throughout the area.

Late hypabyssal intrusions of diabase are situated mainly in the Wathaman Batholith. Probable meteorite impact rocks are exposed on the central island of Gow Lake.

Glacial tills, eskers and glaciofluvial sands and gravels of Quaternary age cover much of the area. Evidence indicates ice flow directions were from the north-northeast or northeast.

Keywords: NTS 74A, Precambrian, Archean basement, Aphebian metasediments, Wollaston Domain, Rottenstone Domain, La Ronge Domain, Wathaman Batholith, Hickson Lake Batholith, Hudsonian Orogeny, Needle Falls Shear Zone, diabase dykes, meteorite crater, petrography, geochemical analyses, geochronology, economic assessment

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Map

193A. Geology of an area around Rottenstone and Dobbin Lakes ..... (back pocket)

Introduction

Location and Accessibility

The area described lies between latitudes 56° 15′ and 56° 45′ north and longitudes 104° 15′ and 105° 15′ west, and corresponds to the NTS sheets 74A-6E, -7, -8W, -9W, -10 and -11E. It is centred in the vicinity of Tremblay Lake 160 km north-northeast of La Ronge and covers an area of 3450 km^2.

The area is most easily reached from La Ronge by float-equipped aircraft. Access within the region is readily made by light aircraft. Also, lakes and rivers suitable for canoe travel are common, especially in the east. Parts of the southwest are troublesome to reach due to the sparsity of large lakes and to the difficulty of negotiating the Taylor River.

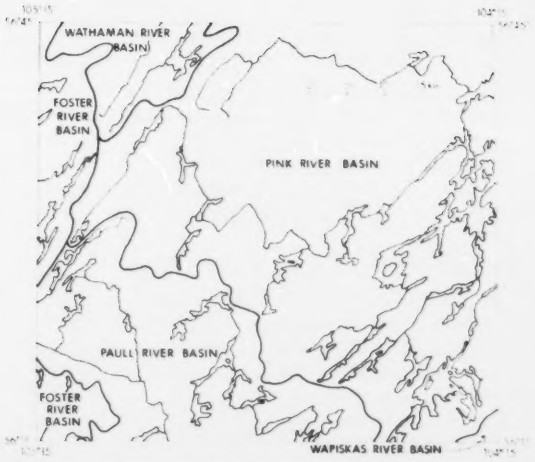

Figure 1. *Drainage system of the map area*

Physiography

The area possesses moderate relief, with hills generally rising 40 to 75 m above adjacent lakes and valley bottoms. The highest land lies along the western edge of the map area where elevations exceeding 550 m are common. Heights of 625 to 630 m are attained between Dobbin Lake and Wilt Lake in the extreme northwest. Altitudes generally decrease eastwards; elevations over 450 m are rare in the vicinity of Deception Lake and Hickson Lake. Pink Lake (387 m) is the lowest part of the area.

The eastern half of the area is mainly within the catchment of the Pink River (Figure 1). The headwaters of the Paull River drain the south, whereas those of the Wathaman River drain the northwest. The eastern part of the Foster River basin occupies the western edge of the area.

Rock outcrop throughout most of the map area is good, and bedrock structure has strongly influenced topography. In particular, the northeasterly trending regional foliation has controlled the orientation of numerous valleys and ridges. Northwesterly valleys result from erosion along major fractures.

Glacial deposits are abundant. Eskers — which are usually oriented north-south or northeast-southwest — form a widespread and prominent feature, as many rise 20 to 25 m above their immediate surroundings. Some eskers, especially those northwest of Hockley Lake and Dobbin Lake, are close to extensive sand plains.

Previous Work

The first serious geological investigations carried out in the map area were prospecting and drilling programs undertaken in 1928 and 1929 by the Consolidated Mining and Smelting Company of Canada Limited around the Rottenstone Lake nickel-copper-platinum-palladium deposit. The deposit has since been described in detail by Mawdsley (1946), and various companies have performed work on it (see Economic Geology).

The earliest geological mapping was conducted in 1936 by McMurchy (1938a, b), who published his results on a scale of 1:253 440 (one inch to four miles). His data were used by Rice (1951) to compile the geological map of the Mudjatik-Geikie region on a scale of 1:506 880 (one inch to eight miles) and by Whitaker and Pearson (1972) for producing the geological map of Saskatchewan.

Other exploration work around Rottenstone Lake and elsewhere in the Foster Lake (central) region was carried out by the Department of Northern Saskatchewan in 1974-75[1] and by various mineral exploration companies from 1959 to 1972 (see Economic Geology). Data produced by these companies are kept as assessment records by Saskatchewan Mineral Resources in Regina.

The area is also included on the following published maps:

(a) 1:63 360 Federal-Provincial aeromagnetic series (1965): maps 2805G (east half), 2806G, 2807G (west half), 2821G (east half), 2822G, 2823G (west half);
(b) 1:253 440 Federal-Provincial regional aeromagnetic series (1966): map 7153G;
(c) 1:250 000 Provincial conductivity anomaly location map (Standing, 1973);

[1]Assessment File 74A11-SE-0039, Saskatchewan Mineral Resources, Regina

(d) 1:250 000 Federal-Provincial National geochemical reconnaissance series (1974), Open File 266, sheet 3 (74-A): individual maps showing concentrations in lake sediments of Fe, Zn, Ag, As, Ni, Co, U, Mo, Cu, Pb and Mn; a twelfth map shows percent loss-on-ignition.

Terminology

Foliation is used to describe any penetrative planar fabric observed in deformed metamorphic rocks and thus includes cleavage and schistosity. *Schistosity* is used to describe the tendency in tectonized rocks towards a common parallel orientation of the crystal elements. *Geometrical fold descriptions*, as suggested by Fleuty (1964), are used in preference to those descriptions with genetic implications. Lack of suitable data has precluded the use of the fold classification proposed by Ramsay (1967).

The nomenclature used in this report to describe coarse- and medium-grained intrusive igneous rocks and metasedimentary rocks are shown in the diagrams for quartz-alkali feldspar-plagioclase (Appendix A, Figure 24) and for mica-total feldspar-quartz (Appendix A, Figure 25) respectively. Where more than one mineral prefix is employed for a particular rock type, the predominant mineral is written first and is followed by other minerals in order of decreasing abundance. The prefixes *leuco* and *mela* are used in accordance with the IUGS recommendations (Appendix A, Figure 26). The term *granitoid* describes any intrusive igneous rock whose quartz content exceeds 20 percent.

Field Work and Acknowledgements

The area was geologically mapped during the summer of 1975 by means of pace-and-compass traverse, with traverses oriented wherever possible perpendicular to the regional strike of the bedrock at 1 to 3 km spacings. The shorelines of the large lakes and some of the small ones were examined in detail using either an inflatable boat or a canoe for transport. Information was plotted daily onto 1:63 360 vertical aerial photograph overlays and 1:63 360 planimetric maps supplied by the Department of Energy, Mines and Resources in Ottawa.

The writer was ably assisted by Andy Bau and Phil Olsen, senior assistants, and by Barry Jones, Anne Wheeler and Dave Worsick, geological assistants. The writer is also grateful to Larry Forseth, Sandy Shatford and Per Wormedal for their expertise as pilots and for their good companionship in camp. The efficient services of the Saskatchewan Mineral Resources staff in La Ronge are appreciatively acknowledged. Cathy Olsen, our cook, kept the field party well fed.

Geochemical analyses and assays were performed at the geochemical laboratory, University of Regina by Brian Watters who kindly wrote Appendix C describing the analytical procedures used.

Quaternary Deposits

Quaternary deposits occur throughout the area but are particularly widespread in the west.

Glaciofluvial sands and gravels, mostly esker-kame delta complexes, are the most distinctive of the Quaternary deposits in the map area. Five main esker systems, trending north-northeast and situated 10 to 15 km apart, form long discontinuous sinuous single ridges or, over short distances, several subparallel ridges. All, but in particular the westernmost three, are laterally bounded in at least a few places by sand plains. These are largely the result of late- and post-glacial erosion of the eskers, which are made up of sand, gravel and well-rounded boulders. The boulders are mostly about 50 cm across and almost always less than 1 m. A few of these sand deposits contain kettle holes. For instance, conical depressions 2 km north of Gow Lake, thought to be kettle holes, are about 50 m across and 15 m deep.

The very extensive and thick sand plain deposits which lie 5 to 10 km west of Deighton and Kenyon Lakes are possibly outwash delta fans.

Surficial cover in areas between esker systems is predominantly glacial till deposited as a thin veneer of sandy material with low silt and clay content (Schreiner et al., 1975). Numerous small boulder fields contain subangular blocks up to about 2 m across. The origin of these fields is uncertain; the blocks appear not to have moved far, as rock types within any field are almost exclusively identical to the underlying bedrock.

Other glacial features are rare. Glacial striations and roches moutonnées are locally preserved on islands and around the shores of Deception and Riehl Lakes. Ice-flow directions from the north-northeast to northeast are indicated.

Precambrian Rock Units

Lewry (1974), Sibbald (1974) and Lewry and Sibbald (1977) have suggested that the southern part of the Precambrian Shield in northern Saskatchewan can be subdivided into lithostructural domains, each of which displays distinctive lithological and/or structural character. The present map area includes parts of three subdivisions, the Wollaston, Rottenstone and La Ronge Domains (Figure 2).

The Wollaston Domain, in the northwestern corner of the area, comprises folded metasediments overlying granitic rocks, the latter exposed in the core of an antiform. Present mapping indicates that the metasediments, termed the Wollaston Group, form a well-defined succession which probably reflects a primary depositional sequence. Similar findings have been made by Ray (1975 and personal communication) to the northwest.

Granitoid rocks from other parts of the Wollaston Domain have yielded radiometric whole rock ages in the range 2000 to 2750 Ma (Money, 1967; Weber et al., 1975 a, b; Cumming and Scott, 1976; Ray and Wanless, 1980); minimum ages are generally accepted by these authors as falling between 2500 and 2750 Ma. Dates younger than 2500 Ma are considered to be the result of updating during subsequent metamorphic events. Mineral separates from the granitoid rocks give K/Ar and Rb/Sr ages of 1700 to 1900 Ma and are interpreted as being indicative of Hudsonian metamorphism. Geochronological studies of metasedimentary rocks give K/Ar and Rb/Sr ages which mostly fall in the 1700 to 1900 Ma range; these are also considered to indicate Hudsonian metamorphism. An older age of 2360 Ma has been obtained by Cumming and Scott (1976), who suggested this figure to be a lower age limit for the metasediments.

The granitic rocks are considered Archean basement, unconformably overlain by Wollaston Group metasediments of Aphebian age. This is supported by the radiometric data, and by direct geological field evidence such as localized occurrences of conglomerate at the base of Wollaston Group lying upon granitic rocks (Money, 1967; Munday, 1974, 1975) and the consistently low stratigraphic/structural position of the granites.

The Wollaston Domain is separated from the Rottenstone Domain to the southeast by a 2.4 to 3.7 km wide north-northeast-trending zone of intense mylonitization and shearing, the Needle Falls Shear Zone.

The Rottenstone Domain in this map area is dominated in its northwestern part by generally massive microcline-bearing granitoid rocks of the Wathaman Batholith and in its southwestern part by a foliated migmatite-tonalite/trondhjemite complex. Irregularly shaped bodies of diabase and a small area of dacitic rocks are also present. Hudsonian radiometric ages in the range 1690 to 1870 Ma have been obtained from the Wathaman Batholith (Ray and Wanless, 1980) and petrologically similar granitoid rocks from other areas in Saskatchewan and northwestern Manitoba (Money, 1967; Weber et al., 1975 a, b), but detailed age and structural relationships of the various rock types are obscure.

The Paull River Shear Zone, made up of strongly deformed rocks of the migmatite-tonalite/trondhjemite complex, separates the Rottenstone Domain from the La Ronge Domain in the southeast corner of the map area. Elsewhere, however, this shear zone is not coincident with the domain boundary (Ray, 1974), which is therefore generally defined by the appearance of cross-cutting massive granitoid and dioritic intrusions emplaced into little-migmatized pelitic metasediments and amphibole schists and gneisses.

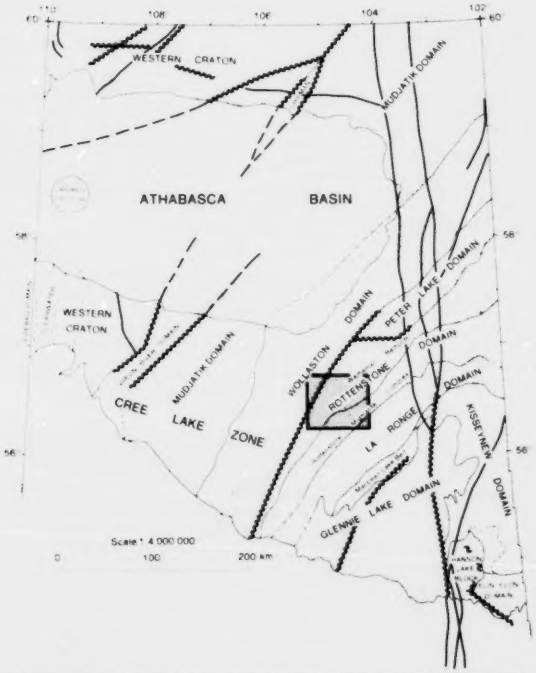

Figure 2. *Location of the map area in relation to the lithostructural domains recognized by Lewry and Sibbald (1977) in northern Saskatchewan*

Wollaston Domain

A well-defined succession has been established (Table 1). The lowermost unit, a foliated monzogranite/syenogranite (Unit 1), is exposed in

Table 1. Succession in the Wollaston Domain

	Biotite monzogranite (Unit 8)
	Biotite ± sillimanite ± muscovite gneisses; semipelites (Unit 7)
	Calc-silicate rocks (Unit 6)
	Quartzofeldspathic rocks; predominantly calcareous arkosic psammites (Unit 5)
Wollaston Group (Aphebian)	Biotite ± cordierite ± sillimanite gneisses; semipelites with characteristic ovoid knots (Unit 4)
	Quartz-muscovite-biotite schists; predominantly pelites (Unit 3)
	Biotite schists and gneisses; pelites with horizons locally rich in muscovite, cordierite, garnet, sillimanite and/or graphite (Unit 2)
	Unconformity
Archean Basement	Hornblende-biotite and biotite monzogranite/syenogranite (Unit 1)

the core of the major northeasterly plunging Anderson Lake antiform. The overlying metasediments (Units 2 to 7) crop out on both flanks of the antiform. The youngest rock type forming a mappable unit in the domain is an intrusive sheet of medium-grained intensely foliated monzogranite (Unit 8).

No primary depositional features, apart from a few exposures of possible conglomerate beds, have been seen in the metasediments of the Wollaston Domain.

Hornblende-Biotite Monzogranite/Syenogranite and Biotite Monzogranite (Subunits 1a, 1b)

These rock types, alias Archean basement, occupy about 30 km^2 along the western border of the map area between Kostyshyn Lake and Lower Foster Lake. They form part of a large granitic mass (the Anderson Lake Inlier) which continues southwestwards through the Barnett Lake area (Money, 1961) into the Pylypow Lake area (Fuh, 1976) and has an overall length of 48 km. They are resistant to erosion and form fairly high and level terrain 500 to 570 m above sea level. The inlier shows up distinctively on aeromagnetic maps (2805G, 2821G) as a region of high and variable magnetic intensity (3700 gammas to over 4700 gammas).

In hand specimen, the monzogranite is typically salmon pink on fresh surfaces, coarse grained and equigranular, with a planar fabric defined by elongated biotite- and/or amphibole-rich patches and by lenticular quartz. Linear fabrics, generally quartz elongation, are well developed in places. Amphibole appears to be increasingly abundant towards the centre of the monzogranite mass, whereas biotite, normally formed at the expense of amphibole, is dominant towards the margins. No xenoliths were seen. Money (1961), however, reports that inclusions are common where the same rock type crops out in the Barnett Lake (west) area. The monzogranite is cut by undeformed pink pegmatite and by a massive medium- to fine-grained syenogranite. Five thin sections of hornblende-biotite monzogranite/syenogranite (Subunit 1a) were examined (Table 2); two are syenogranite and three are monzogranite. Six thin sections of biotite monzogranite (Subunit 1b) were studied (Table 3).

In Subunit 1a, *hornblende* is pleochroic in moderate to dark shades of green and moderate shades of brown. The mineral forms ragged grains and poikiloblastically encloses opaque ore, quartz, plagioclase, apatite and zircon. It is partially altered to and intergrown with biotite. In both Subunits 1a and 1b, *biotite* is dichroic from pale yellowish brown to moderate or dark brown. Flakes are well oriented in some sections (0172, 0285, 0286, 0303), randomly oriented in others (0173, 0287). Pleochroic haloes are moderately abundant around inclusions of zircon or apatite. Rare alteration to chlorite parallel to cleavage planes has been observed (0287).

Quartz forms multigrained patches in which individual grains are irregularly shaped and show extreme undulose extinction. They are variably fractured and flattened. Intergranular boundaries are highly irregular and in some sections (0172, 0284) are sutured. *Plagioclase* is of oligoclase composition and is generally weakly sericitized. Grains are large, possess clear albitic margins and enclose small grains of quartz and very rarely biotite and microcline. Many plagioclase grains have slightly bent multiple twin lamellae. *Microcline* is present as both large and small, very irregularly shaped, fresh, cross-hatched crystals which contain inclusions, most commonly of quartz but also of plagioclase and biotite. The mineral characteristically exhibits string and ribbon perthite; some grains also show patch perthite.

Ubiquitous *accessory minerals* include idioblastic zircon, apatite and opaque ore[1] (ranging up to about 2 percent), some grains of which have narrow partial rims of sphene. Subunit 1b in addition contains

[1]Includes mainly the sulphides and iron oxides

accessory chlorite, epidote and sericite as alteration products of mafic minerals and plagioclase.

The texture of the monzogranite/syenogranite is typically xenoblastic granular. Cataclastic effects are rare and were observed in only one thin section (0172).

Massive medium- to fine-grained syenogranite was found at one locality in the core of the Anderson Lake Inlier. Although its contacts with the surrounding biotite-hornblende monzogranite were not seen, it is thought to represent a younger intrusive phase, possibly a remobilizate, into the main granitoid mass. Thin section examination (0174, Table 4) shows this rock to be made up of 10 percent small (less than 1 mm long) randomly oriented flakes of pale yellowish brown to dark brown biotite, 35 percent small strained evenly distributed quartz grains, 15 to 20 percent small fresh crystals of plagioclase (albite) and 40 percent microcline. Accessory zircon and opaque ore minerals are highly irregular in shape.

The contact between the Anderson Lake monzogranite/syenogranite and the metasediments of the Wollaston Group appears to be structurally concordant. No features indicative of intrusion of the Anderson Lake Inlier into the surrounding metasediments were seen. Conductor horizons, apparently due to the presence of graphite, have been located in the metasediments at several points around the nose of the antiform close to the metasediment-granite contact, suggesting the possibility of a continuous stratigraphic unit. These graphitic horizons are known to occur at or very close to similar metasediment-granite contacts in nearby

Table 2. Modal compositions of hornblende-bearing rocks of the Anderson Lake Inlier (Subunit 1a), Wollaston Domain

Dept. No. 7508-	Rock Name	Biotite	Hornblende	Quartz	Plagioclase	Microcline	Accessory Minerals
0173	Hornblende-biotite syenogranite	3x	10	27	15* (oligoclase)	35 (s,p)	Zr, Ap, Op, Sph
0180	Hornblende-biotite monzogranite	3*	7*	30	20 (oligoclase)	40 (s)	Zr, Ap, Op, Sph
0191	Biotite-hornblende syenogranite	6x	4	25‖	15** (oligoclase)	50 (s)	Zr, Ap, Op, Sph
0288	Hornblende-biotite monzogranite	1	5	35	30* (oligoclase)	29 (s)	Zr, Ap, Op, Sph
0318	Hornblende monzogranite	Trace	4	31	29 (oligoclase)	36 (s)	Zr, Ap, Op, Sph (?)

See Appendix B for explanation of symbols used.
Underlined samples have been geochemically analyzed.

Table 3. Modal compositions of hornblende-free rocks of the Anderson Lake Inlier (Subunit 1b), Wollaston Domain

Dept. No. 7508-	Rock Name	Biotite	Quartz	Plagioclase	Microcline	Accessory Minerals
0172	Cataclastic biotite monzogranite	5‖ *	20‖	30* (oligoclase)	35	Zr, Ap, Op
0284	Biotite monzogranite	5	33	29* (oligoclase)	33 (s)	Zr, Ap, Chl
0285	Biotite monzogranite	5≈	20≈	30* (oligoclase)	45 (s)	Zr, Ap, Op
0286	Biotite monzogranite	3≈	35≈	27* (oligoclase)	35 (s)	Zr, Ap, Op, Sph, Ep
0287	Chloritized biotite monzogranite	3x**	35	27* (oligoclase)	35 (s)	Zr, Ap, Op, Chl
0303	Biotite monzogranite	5≈	40	20 (oligoclase)	35 (s)	Zr, Op, Ep, Ms

See Appendix B for explanation of symbols used.
Underlined samples have been geochemically analyzed.

Table 4. Modal composition of fine-grained syenogranite in the Anderson Lake Inlier, probably an intrusive phase into hornblende-biotite monzogranite (Subunit 1b)

Dept. No. 7508-	Rock Name	Biotite	Quartz	Plagioclase	Microcline	Accessory Minerals
0174	Massive fine-grained syenogranite	10x	35	15 (albite)	40	Zr, Op

See Appendix B for explanation of symbols used.

areas (Mawdsley, 1957; Ray, 1980), indicating the stratigraphic unit is of large regional extent. A likely inference is that the graphite horizon was deposited on an unroofed granitic mass, a relationship proposed by Munday (1974) and Money (1967) for polymictic conglomerates directly overlying granitic rocks at the base of Wollaston Group metasediments farther south.

At and around the nose of the Anderson Lake antiform, the contact rocks are highly quartzofeldspathic and are finer grained than the monzogranite/syenogranite. At one locality within 100 to 200 m of the southeast shore of Jenny Lake, a deformed fine- to medium-grained calcareous meta-arkose is exposed. In thin section (0148, 0283, Table 5), 50 to 65 percent quartz is seen as a network of small highly strained grains with sutured boundaries and some elongation parallel to the main foliation; 5 to 30 percent microcline is mainly interstitial within the quartz network; and 17 percent plagioclase is present in section 0283, where it is extensively fractured and sericitized. In addition, 3 percent diopsidic pyroxene and, as alteration products, 2 percent tremolite, epidote and carbonate are present. In contrast, section 0148 has zones consisting mainly of sericite, epidote and almost colourless biotite; small xenoblastic grains of garnet, diopside and tremolite are also present. Accessory minerals include opaque ore, zircon, carbonate and chlorite. Sample 0283 has been geochemically analyzed for major oxides (Table 54).

Southeastwards, around the nose of the antiform, quartzofeldspathic gneiss crops out close to the contact (56° 37′ 36″N; 105° 10′ 46″W). In thin section (0149, Table 5), it is found to contain 10 percent biotite which forms small generally well-oriented flakes and is dichroic from pale straw yellow to moderate or dark brown; 35 percent quartz as small irregularly margined grains with extreme undulose extinction; 35 percent microcline; and 28 percent fresh albitic plagioclase.

No direct contacts between basement granite and the overlying metasediments were examined, as exposure at the junction is extremely poor.

Biotite Schists and Gneisses (Unit 2)

A total area of about 55 km^2 is occupied by this unit. Around Split Lake in the hinge of the Anderson Lake antiform, the ground is level and varies in elevation from 550 to 580 m. These schists and gneisses form more dissected topography along the limbs of the antiform. The unit passes through Lower Foster Lake on the northwestern limb and through Kostyshyn Lake on the southwestern limb. The thickness of the unit varies from about 1500 m around Lower Foster Lake to 800 m around Kostyshyn Lake. Four lenses of this unit also crop out to the southeast of the sheet-like monzogranite (Unit 8) and the quartz-muscovite-biotite schists (Unit 3), and are represented by samples 0184 and 0309.

The unit is pelitic with minor semipelitic and arkosic horizons. Amphibole-bearing bands are present but rare. In hand specimen, the unit is generally a medium-grained rock. Crystals up to 5 mm across of both biotite and muscovite sharply transect the main schistosity. Estimated modes of 17 samples based on thin section examination are presented in Table 6. Modes of the samples representing the four outlying lenses of the unit are given in Table 7.

The total mica content is typically in the range 25 to 50 percent. *Biotite* is commonly fresh and shows good preferred orientation. The flakes are dichroic from a pale brown or straw yellow to moderate brown (0157, 0184, 0304, 0309, 0310) or moderate reddish brown (0147, 0179, 0183, 0190, 0317). The darkest brown shades are seen in sections 0181 and 0182, but are not as dark as in many of the rocks in the area that are of igneous derivation. Pleochroic haloes are numerous in some sections (0147, 0181, 0304, 0317). Chloritization has been observed in two sections (0182, 0306). Although flakes oblique to the main schistosity are found in many sections, they define a distinct second schistosity in only one (0179). Here a few biotite, muscovite and graphite flakes are parallel to the axial planes of crenulations which deform the main schistosity. *Muscovite* is generally well oriented parallel to the main schistosity. Kinking and fracturing of crystals is well displayed in several sections (0157, 0310).

Table 5. Modal compositions of rocks at the contact between the Anderson Lake inlier (Subunits 1a, b) and overlying, predominantly pelitic metasediments (Unit 2) of the Wollaston Group

Dept. No. 7508-	Rock Name	Biotite	Amphibole and/or Pyroxene	Garnet	Epidote	Quartz	Plagio-clase	Micro-cline	Accessory Minerals
0148	Garnet-bearing calcareous psammite	Trace	Trace (Tr+Di)	Trace	30 (including Se+Bt+Chl)	65‖	-	5	Zr, Op‖, Sph, Cbt
0149	Psammitic biotite gneiss	10‖ x	-	-	-	35	20	35	Zr, Ap, Op
0283	Calcareous psammite	Trace	5 (Tr+Di)*	-	-	48	17**	30	Zr, Op, Cbt, Chl

See Appendix B for explanation of symbols used.

Table 6. Modal compositions of predominantly pelitic biotite schists and gneisses forming the basal unit (Unit 2) of the Wollaston Group

Dept. No. 7508-	Rock Name	Biotite	Muscovite	Amphibole	Cordierite	Garnet	Sillimanite	Quartz	Plagioclase	Microcline	Accessory Minerals
0137	Pelitic muscovite-cordierite-biotite-sillimanite schist	15‖	25‖ x	-	18	-	Present in Co	33	?	9	Zr, Op, Sph
0139	Pelitic biotite-garnet gneiss	25‖	-	-	-	3	-	25	35	12	Zr, Ap, Op
0146	Pelitic muscovite-sillimanite gneiss	Trace	30x	-	-	-	Present in Ms	45	25	Trace	Zr, Ap(?), Op
0147	Pelitic biotite-sillimanite gneiss	30	Trace	-	-	-	Present‖ with Ms‖	15	15	45	Zr, Ap, Op
0150	Psammitic cordierite-sillimanite gneiss	Trace x	Trace x	-	30**	-	Present‖ in Co	50	Trace	20	Zr, Op, To
0157	Pelitic biotite-muscovite-sillimanite gneiss	20‖ x	5	-	-	-	Present in Bt, Ms, Qz	30	15	30	Zr, Op
0179	Pelitic biotite-muscovite-graphite gneiss	25‖#	15‖# x	-	-	-	-	←———	45	———→	Gr(15‖), Zr, Ap, To, Ep
0181	Semipelitic biotite gneiss	20‖ x	-	-	-	-	-	25	50 (oligoclase)	5	Zr, Ap, Op, Sph
0182	Psammitic biotite gneiss	5‖ **	-	-	-	-	-	30"	25 (albite)*	38	Zr, Op (?), Chl
0183	Semipelitic biotite-garnet schist	12	-	-	-	1	-	57"	30*	Trace	Zr, Ap, Op
0190	Contact of pelitic biotite-garnet gneiss with hornblende gneiss	25‖	-	-	-	5	-	30‖	40	-	Zr, Op
		-	-	30 (Hb)	-	-	-	←---	70 ---→ **	-	Ap, Op, Sph, Cbt, Cz
0192	Semipelitic biotite-hornblende gneiss	12‖ x	-	7 ≈(Hb)	-	-	-	20	35 (oligoclase)*	25	Zr, Ap, Op (1), Sph
0304	Pelitic biotite-muscovite-sillimanite schist	15‖	15x	-	-	-	Present in Ms	Trace	38	32	Zr, Ap, Op
0305	Metagabbroic (?) actinolite-rich rock	-	-	85 (Act)	-	-	-	Trace	15**	-	Ap, Op, Sph, Se, Ep
0306	Pelitic biotite-muscovite-sillimanite gneiss	25‖ *	5	-	-	-	Present in Ms	20	40	10	Zr, Op, Chl
0310	Pelitic muscovite-biotite gneiss	20	30	-	-	-	-	25	25	-	Zr, Ap, Op
03[illegible]	Semipelitic biotite-muscovite-sillimanite gneiss	15‖ x	5‖ x	-	-	-	Present with Ms	Trace	20	60	Zr, Ap, Op

See Appendix B for explanation of symbols used.

Table 7. Modal compositions of pelitic schists of the Wollaston Group (Unit 2) which outcrop as lenses southeast of the sheet-like monzogranite (Unit 8) and/or the quartz-muscovite-biotite schists (Unit 3)

Dept. No. 7508-	Rock Name	Biotite	Muscovite	Quartz	Plagioclase	Microcline	Accessory Minerals
0184	Pelitic biotite schist	30‖ x	-	45‖	20(albite?)	-	Op (5%), Ap, Sph
0309	Sheared pelitic muscovite-biotite-quartz schist	7‖	18‖	60‖	15*	Trace	Zr

See Appendix B for explanation of symbols used.

Sillimanite needles have been observed in many sections. They tend to form well-oriented, locally contorted, felted helicitic trains enclosed in cordierite (0150) or in flakes of muscovite 5 to 7 mm across. *Cordierite* has been recognized in two sections (0137, 0150) as lenticular aggregates in which individual crystals are xenoblastic and show rudimentary multiple twinning. Yellow pleochroic haloes surround enclosed zircon grains. Strong alteration to pinite was observed in one section (0150). *Garnet*, present in three sections (0139, 0183, 0190), forms xenoblastic crystals up to 1 cm across which are full of weakly oriented (0139, 0190) and unoriented (0183) biotite, quartz and/or plagioclase. Pressure-shadow areas made up of microcline, quartz and plagioclase flank garnet in section 0139. *Amphibole* where present is a xenoblastic well-oriented mineral pleochroic in shades of pale to moderate brown and green. It is hornblendic in two sections (0190, 0192), actinolitic in a third (0305). Poikiloblastic inclusions of quartz and saussuritized plagioclase are typical (0190, 0192).

Quartz forms variably sized, very irregularly shaped, strained grains. A slight to pronounced crystal elongation parallel to the main foliation has been noted in sections 0157, 0182, 0183 and 0190. In section 0309, the quartz locally develops a ribbon texture. Some interquartz boundaries are sutured

(0181, 0183, 0184). *Plagioclase* is usually fresh, displays multiple twinning, and compositionally ranges from albite (0146, 0182, 0184) to oligoclase (0157, 0181, 0192). Slight sericitization affects plagioclase rarely (0182, 0183, 0190, 0305, 0309). *Microcline* is comon, forming fresh clear irregularly shaped grains. Perthitic exsolution lamellae are present in some sections (0150, 0157, 0182, 0192, 0317), and inclusions of quartz, plagioclase and mica occur in large grains (0150, 0157).

The most widely developed *accessory minerals* are zircon, apatite, opaque ore and sillimanite. Less common accessories include sphene, tourmaline, epidote, clinozoisite, carbonate, chlorite and graphite (15 percent of the rock in section 0179).

Contacts between Unit 2 and the overlying pelitic muscovite-biotite schists are gradational, particularly on the northwest limb of the Anderson Lake antiform. On the southeast limb these two units are separated by a sheet of foliated monzogranite (Unit 8).

Quartz-Muscovite-Biotite Schists (Unit 3)

About 30 km^2 of the map area is underlain by quartz-muscovite-biotite schists, in a band that is narrow (150 to 600 m) on the flanks of the Anderson Lake antiform but wider and more flat lying in the hinge zone. Along the southeastern flank the schists typically have a whitish colour and are flaggy, splitting along micaceous partings. Their subvertical north-northeast-trending main schistosity is deformed by a vertical crenulation cleavage which strikes between north and north-northwest. Granitic veins up to 1 cm wide lie parallel to this cleavage. Along the northwestern flank of the antiform the quartz-muscovite-biotite schist is pink due to an increased microcline content and the flaggy nature of the rock is less well developed.

Pale pink muscovite ± tourmaline ± garnet pegmatites are a common minor intrusive phase particularly in the hinge zone of the Anderson Lake antiform, and on its southeastern flank where they make up about 15 percent of rock outcrop adjacent to the monzogranite intrusion (Unit 8). Estimated modes of six samples are given in Table 8.

Muscovite flakes up to 7 mm in size are mostly well oriented and define the main schistosity. Some flakes are deformed by tight folds (0144) or by the more open crenulation cleavage (0156, 0162); however, many of these flakes are mimetically recrystallized around hinges of the tight folds and a few are oriented parallel to the crenulation cleavage. Muscovite crystals cutting across these early fabrics are also common (0144, 0145). *Biotite* flakes are fresh and dichroic from very pale to pale shades of straw yellow or brown. Their growth and deformation relationships are similar to those described for muscovite. *Graphite* is present mainly as small to moderately sized (5 mm) grains oriented parallel to the main schistosity and folded by later deformations (0144). It occurs interleaved with muscovite (0144) or as intergranular material between felsic minerals (0143).

Quartz shows pronounced elongation, mostly parallel to the main schistosity (0143, 0145, 0162, 0307) but also parallel to the crenulation cleavage (0156). Extreme undulose extinction and sutured interquartz boundaries (0143, 0145, 0156, 0162) are characteristic. No annealing was recognized. *Feldspar* where present is fresh. Plagioclase displays multiple twinning; the An content was not determined. The granitoid veins parallel to the crenulation cleavage comprise about 70 percent quartz and 30 percent plagioclase (0156).

Accessory minerals are zircon (including a characteristic xenoblastic multizoned variety),

Table 8. Modal compositions of predominantly pelitic quartz-muscovite-biotite schists of the Wollaston Group (Unit 3)

Dept. No. 7508-	Rock Name	Muscovite	Biotite	Graphite	Quartz	Plagio-clase	Micro-cline	Accessory Minerals
0143	Sheared psammitic biotite-muscovite (-graphite ?) schist	5	5	5 ?	35 ∥	15	35	Zr, Op
0144	Folded pelitic muscovite-graphite schist	55 ∥ x	-	25 ∥	10	Trace	10	To
0145	Sheared pelitic quartz-muscovite-biotite schist	20 ∥ x	10 ∥ x	-	70 ∥	Trace	Trace ?	Zr, Ap, To
0156	Folded semipelitic quartz-muscovite-biotite schist	15 ∥ #	5 ∥ #	-	50 #	30	-	Zr, Ap
0162	Pelitic quartz-muscovite-biotite schist	25 ∥ #	10 ∥ #	-	65 ∥	-	-	Zr, Ap
0307	Folded pelitic muscovite-biotite schist	35 ∥	20 ∥	-	30 ∥	15	Trace	Zr, Ap, Op

See Appendix B for explanation of symbols used.

apatite, small subidioblastic to idioblastic tourmaline, and opaque ore.

On the northwestern limb of the Anderson Lake antiform, the upper contact of the quartz-muscovite-biotite schist is gradational into semipelitic biotite gneisses (Unit 4). However, on the southeastern limb of the antiform, the unit grades along most of its length directly into meta-arkosic psammites (Unit 5), but locally into pelitic biotite schists identical to those in Unit 2.

Biotite ± Cordierite ± Sillimanite Gneisses (Unit 4)

Biotite ± cordierite ± sillimanite gneisses underlie two small portions, together totalling approximately 15 km^2 of the northwestern corner of the area. Their thickness ranges from 300 to 700 m. The unit is more resistant to erosion than the pelitic rocks of Units 2 and 3 and forms rugged steep-sided outcrops rising 30 to 40 m above adjacent valley bottoms. Leucocratic ovoid knots of quartz and/or feldspar, sillimanite and cordierite are abundant. They are 1 to 4 cm long with their major axes parallel to S_1. Estimated modes of five samples are given in Table 9.

Biotite flakes are commonly well oriented and define the main schistosity, but in several sections (0130, 0140) they also cut sharply across this foliation. The mineral is dichroic from pale straw yellow or pale brown to moderate brown. *Cordierite* occurs as part of the rock groundmass (0131), and also in the centres of leucocratic knots (0131, 0140) where it contains inclusions of fibrous sillimanite, biotite and quartz but commonly weathers out. It is fresh, shows multiple twinning and possesses yellow pleochroic haloes around enclosed zircon (0131, 0140). *Sillimanite* (as fibrolite) is enclosed within cordierite and is either randomly oriented (0141) or parallel to the main schistosity (0158).

Quartz is strained and fractured and is slightly elongated parallel to the biotite schistosity in one section (0731). *Plagioclase* forms grains 0.5 to 2 mm across. These grains are slightly cloudy in places (0158) due to enclosed opaque ore dust. *Microcline* is present both in the matrix and with quartz as a marginal phase to the ovoid knots. Large grains of this mineral enclose rounded blebs of quartz and plagioclase (0132).

Of the *accessory minerals*, zircon and opaque ore (up to 3 percent) are invariably present. Muscovite, mostly interleaved with biotite, is generally present. Apatite and tourmaline are common, the tourmaline mainly concentrated with the knots.

With a gradual disappearance of leucocratic knots and biotite, the pelitic and semipelitic gneisses grade into quartzofeldspathic rocks (Unit 5).

Quartzofeldspathic Rocks (Unit 5)

Fine- to medium-grained quartzofeldspathic rocks of probable sedimentary origin crop out along both flanks of the Anderson Lake antiform. To the northwest of the antiform they appear to occupy the core of a synform and to the southeast are adjacent to the mylonites of the Needle Falls Falls Shear Zone. They typically form smooth clean rounded well-jointed outcrops of pale grey and/or pink mica-poor rocks in which planar fabrics are variably developed. Considerable partial melting and/or recrystallization of felsic minerals has taken place, resulting in segregations of medium-grained granite which lack regular trends and well-defined margins. Grains of opaque ore are the most readily observed mafic mineral; where granitic segregations have developed, these grains tend to concentrate within them. A colour banding is caused by a coating of hematite around felsic minerals and is often the only

Table 9. Modal compositions of semipelitic biotite ± cordierite ± sillimanite gneiss (Unit 4) of the Wollaston Group

Dept. No. 7508-	Rock Name	Biotite	Cordierite	Sillimanite	Quartz	Plagio-clase	Micro-cline	Accessory Minerals
0130	Semipelitic biotite gneiss	20 ‖ x	-	-	27	← 35 ——	-- ? --→	Zr, Op
0131	Pelitic cordierite-biotite-sillimanite gneiss	15 ‖	35	Present in Co	35 ‖	3	12	Zr, Ap, Op, Ms
0132	Semipelitic biotite-cordierite-sillimanite gneiss	10x	5	Present in Co	40	?	40	Zr, Op, Ms
0140	Semipelitic biotite-cordierite-sillimanite schist	22 ‖ x	Knots of complex intergrowths large cordierite full of sillimanite x		←—— 78 ——→			Zr, Ap, Op, Ms, To
0158	Pelitic biotite-cordierite-sillimanite gneiss	20 ‖	10	Present in Co ‖	33	?	34	Zr, Ap, Op (3%), Ms, To

See Appendix B for explanation of symbols used.

planar fabric present. Although it is parallel to planar mineral fabrics where these are recognized, this colour banding could represent either original bedding or a thermotectonic fabric (cf. Scott, 1973, p. 9). Thin sections of four samples taken on the northwestern limb of the Anderson Lake antiform were examined (Table 10).

Biotite is present as random to weakly oriented flakes dichroic in shades of very pale straw yellow and brown. In places the mineral is later than and partly replaces tremolite-actinolite (0135). *Tremolite-actinolite* is found as poikiloblasts, pleochroic in extremely pale shades of green and brown, and locally strained and fractured.

Quartz grains, generally 0.5 to 1.5 mm across, are strained and have complexly interlocking margins. The mineral has a preferred dimensional orientation which imparts a weakly defined schistosity to otherwise massive rocks (0127, 0128, 0135); the quartz is ribboned in one slide (0128). *Plagioclase* is of oligoclase (An_{25-30}) composition and exhibits some slight alteration. Fresh cross-hatched *microcline* is abundant.

Accessory minerals include ubiquitous zircon and sphene, widespread apatite and opaque ore (up to 3 percent), and rare epidote, carbonate, chlorite, allanite, tourmaline, sillimanite and muscovite (up to 5 percent).

Crystal boundaries are highly irregular and lack the granoblastic textures and triple-point junctions indicative of late annealing.

Five thin sections from the band of quartzofeldspathic rocks on the southeastern limb of the Anderson Lake antiform have been examined (Table 11). Two of these (0163, 0308) from the same outcrop consist of actinolite and epidote ± microcline ± diopside ± sphene and may be metamorphosed calc-silicate rocks. A third section (0153), also possibly a metamorphosed calc-silicate, is mafic rich and felsic poor. The two remaining sections (0164, 0314) are of typical finely crystalline arkosic psammite, in which the foliation is defined by concentration of tremolite and the opaque ore minerals, and by variation in grain size. Intergranular boundaries are highly irregular or sutured.

With increasing content of calc-silicate minerals such as tremolite-actinolite, diopside, scapolite and epidote, and with carbonate present, these arkosic psammites grade into calc-silicates (Unit 6).

Table 10. Modal compositions of predominantly quartzofeldspathic rocks (Unit 5) of the Wollaston Group which crop out on the northwestern limb of the Anderson Lake antiform

Dept. No. 7508-	Rock Name	Biotite	Muscovite	Tremolite	Quartz	Plagio-clase	Micro-cline	Accessory Minerals
0126	Semipelitic muscovite-biotite-sillimanite gneiss	7	8	-	50	10 *	30	Si (in Qz), Zr, Op, Sph, To
0127	Arkosic tremolite-bearing psammite	-	-	5	50	25	25	Zr, Ap, Op, Sph, Ep, Cbt, Al
0128	Sheared arkosic biotite-tremolite psammite	5x*	-	2	30	30 *	30	Zr, Ap, Op (3), Sph, Ep, Chl
0135	Arkosic biotite-tremolite psammite	2	-	2	38	38 *	18	Zr, Ap, Op, Sph

See Appendix B for explanation of symbols used.

Table 11. Modal compositions of predominantly quartzofeldspathic rocks (Unit 5) of the Wollaston Group which crop out on the southeastern limb of the Anderson Lake antiform adjacent to the Needle Falls Shear Zone

Dept. No. 7508-	Rock Name	Biotite	Muscovite	Tremolite	Quartz	Plagio-clase	Micro-cline	Accessory Minerals
0153	Garnet-tremolite-biotite schist	22	-	23	Trace	Trace	-	Gt (55%), Zr, Ap, Op, To
0163	Actinolite-epidote gneiss	-	-	40(Act)	5	-	30	Ep (25%), Op, Sph
0164	Arkosic diopside-tremolite psammite	-	-	5(Di+Tr)	←90 (albite ?)→		?	Op (5%), Sph
0308	Foliated actinolite-diopside-epidote rock	Diopside cores surrounded by actinolitic amphibole, epidote, clinozoisite and sphene; microcline and quartz in viens						
0314	Arkosic tremolite-bearing psammite	Trace	-	Trace	25	75	?	Zr, Ap, Op, Sph

See Appendix B for explanation of symbols used.

Calc-Silicate Rocks (Unit 6)

Calc-silicate rocks are interbanded with arkosic psammite on a scale of several centimetres up to several hundred metres. The four outcrops of the rock shown on the geological map appear to represent lenses, each occupying an area slightly greater than 1 km^2. The rock is resistant to erosion and forms high-standing exposures which have coarsely granular, pale to moderate grey, rough weathered surfaces. Crystals of green amphibole (actinolite) up to 10 cm long have been seen in outcrop. Estimated modes of five samples are given in Table 12.

Diopside forms poikiloblasts over 5 mm wide enclosing grains of quartz and carbonate (0133). *Tremolite-actinolite* is colourless or pleochroic in very pale shades of green and is randomly oriented. In one section (0134) large xenoblastic porphyroblasts about 5 mm long enclose rounded blebs of carbonate and highly strained quartz. In section 0138 grains greater than 3 mm across show marked undulose extinction; smaller grains in the same section display slight concentration parallel to bands of opaque ore grains. *Scapolite*, present in two sections (0129, 0136), is xenoblastic and considerably altered along cleavage planes. Very pale brown *biotite* also occurs in these two sections; in 0136 it is an alteration product of tremolite-actinolite. *Carbonate* occurs in sections 0133 and 0134 as equigranular poorly shaped grains 2 to 3 mm across; most boundaries are irregular but a few in 0134 are straight.

Quartz is highly strained with slight elongation in two sections (0133, 0136). Elsewhere a mortar texture is developed around the edges of some grains and along narrow shear zones (0138). In section 0129 the mineral is finely granular and in places ribboned. *Plagioclase* occurs as oligoclase-andesine. *Microcline* is abundant in the groundmass of one section (0136) and in another (0129) forms strained porphyroblasts which are recrystallized along fractures.

Accessory minerals include sphene (present in all thin sections), tourmaline, opaque ore, apatite, epidote and chlorite.

Subgranoblastic textures are developed in two sections (0134, 0138), while grain boundaries in the others are highly irregular, or sutured as in 0129.

Biotite ± Sillimanite Gneisses (Unit 7)

Several outcrops of medium-grained semipelitic to psammitic gneisses are located between mappable units of quartzofeldspathic rock (Unit 5) in the northwest corner of the map area. They are considered to form part of a unit that occupies the core of a synform. However, exposure is exceptionally poor, as one of the major esker/glaciofluvial sand and gravel complexes mantles most of the area (10 km^2) assumed to be underlain by these semipelitic gneisses. No petrographic studies were done on samples from this unit.

Biotite Monzogranite (Unit 8)

A large sill, 22 km long and from 250 to 700 m wide, of medium-grained, intensely foliated, non-porphyroblastic pink monzogranite cuts metasediments of the Wollaston Group on the southeast limb of the Anderson Lake antiform. It lies mainly between pelitic biotite schists and gneisses (Unit 2) and pelitic quartz-muscovite-biotite schists (Unit 3), and displays sharp contacts with both. Banded migmatite is developed in adjacent pelitic biotite schists and gneisses of Unit 2 and pegmatites, many of which are foliated, occur in the quartz-muscovite-biotite schists of Unit 3. The modal composition of the single thin section examined from this unit is shown in Table 13.

Biotite is present as small well-oriented flakes, dichroic from pale yellowish brown to dark brown, and is slightly altered to chlorite along cleavage

Table 12. Modal compositions of calc-silicate rocks (Unit 6) of the Wollaston Group

Dept. No. 7508-	Rock Name	Diopside	Tremolite	Scapolite	Biotite	Carbonate	Quartz	Plagioclase	Microcline	Accessory Minerals
0129	Scapolite-tremolite-diopside-biotite-feldspar-quartz calc-silicate	3	5	5	2	-	10	35	40	Zr, Ap, Sph
0133	Carbonate-diopside-quartz calc-silicate	30	-	-	-	50	20	-	-	Sph, To
0134	Carbonate-tremolite-quartz calc-silicate	-	40	-	-	55	5	-	-	Sph
0136	Scapolite-tremolite-biotite-feldspar-quartz calc-silicate	-	5x*	10**	3	-	28	5 *	47	Ap, Op (2), Sph, Ep, Chl
0138	Calcareous tremolite-bearing psammite	-	5	-	-	-	50	45	-	Zr, Op, Sph

See Appendix B for explanation of symbols used.

Table 13. Modal composition of the sheet-like mass of monzogranite (Unit 8) injected into metasediments of the Wollaston Group on the southeastern limb of the Anderson Lake antiform

Dept. No. 7508-	Rock Name	Biotite	Quartz	Plagioclase	Microcline	Accessory Minerals
0176	Foliated biotite monzogranite	10‖*	30	20 *	40	Zr, Ap, Op, Sph, Al

See Appendix B for explanation of symbols used.

planes. *Quartz* is strained and elongated parallel to the biotite schistosity; it has extremely irregular margins. Small grains (approximately 1 mm across) are evenly distributed throughout the section. *Plagioclase* is cloudy due to sericitization. Small amounts of myrmekite occur at plagioclase/microcline contacts. The texture is xenoblastic.

Needle Falls Shear Zone

The three main lithologic units comprising the Needle Falls Shear Zone — mylonite (Unit 9), metagabbro/metadiorite (Subunit 15a) and augen gneiss (Subunit 15b) — indicate progressive decrease in intensity of shearing to the southeast. Subunits 15a and b are in many places obscured by sand and gravel. The mylonitic rocks are closely coincident with a linear zone showing a steep magnetic gradient from 3600 to 3800 gammas on aeromagnetic map 2805G of the Middle Foster Lake area. The augen gneisses characteristically possess high magnetic intensities of 3800 to 4100+ gammas.

Mylonite (Unit 9)

Mylonite, underlying an area of approximately 13 km^2, has slightly higher relief than adjacent rock types. It is very fine grained, well foliated and typically weathers to a pale buff or pink colour. In places the unit contains segregation patches, up to 5 cm in diameter, of coarse-grained actinolite. The mylonite, generally very siliceous, has been mapped in the past as flow-banded rhyolite[1].

Conglomerate has been described[2] in a stretch of mylonite extending from the north end of Astleford Lake to north of Meg Myles Lake[3]. A rock containing deformed and largely rounded fragments was seen in that locality during the present survey but was not mapped separately. The fragments, measuring up to 15 cm across, are of well-banded to massive, fine-grained meta-arkose. Banding within these meta-arkosic fragments shows rotation relative to other neighbouring fragments. The clasts are very poorly supported in a well- to weakly foliated pink or grey matrix containing randomly oriented porphyroblasts of amphibole (5 to 30 percent). The matrix, however, appears to be of ignecus intrusive origin in some localities and the rock is therefore labelled a pseudoconglomerate (Figure 3).

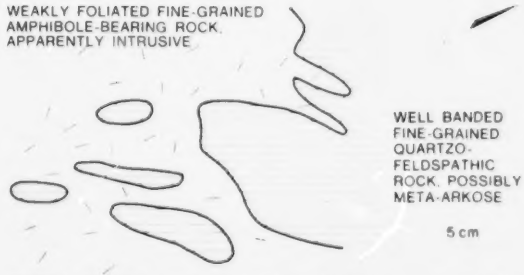
WEAKLY FOLIATED FINE-GRAINED AMPHIBOLE-BEARING ROCK, APPARENTLY INTRUSIVE
WELL BANDED FINE-GRAINED QUARTZO-FELDSPATHIC ROCK, POSSIBLY META-ARKOSE
5 cm

Figure 3. *Sketch showing "pseudoconglomerate" composed of poorly supported, rounded to subangular clasts of banded metasedimentary rock in weakly foliated fine-grained amphibole-bearing matrix (samples 0155, 0177, 0187) of apparent intrusive origin, north end of Astleford Lake (56° 35' 41"N; 105° 09' 00"W)*

The rocks in this mylonitic zone appear to have been derived from several sources, predominantly intrusive granitoids and Wollaston Group metasediments. Microscopic examinations were carried out on five representative samples of the granitoids (0141, 0142, 0154, 0165, 0186), three samples of pseudoconglomerate (0155, 0177, 0187) and three samples of probable sedimentary origin (0166, 0178, 0185). Modal compositions are shown in Table 14.

Biotite is present in the granitoids as tiny well-oriented flakes, dichroic in shades of pale brown and considerably altered to randomly oriented chlorite.

Quartz occurs both as small grains with straight boundaries showing little evidence of undulose extinction (0142) and as ribbon-like grains with sutured boundaries (0141). Most are variably

[1]Assessment File 74A11-NE-0014, Saskatchewan Mineral Resources, Regina

[2]Assessment File 74A11-SE-0039, Saskatchewan Mineral Resources, Regina

[3]unofficial lake name

Table 14. Modal compositions of highly deformed mylonites (Unit 9) of the Needle Falls Shear Zone, separating the Wollaston Domain from the Rottenstone Domain

Dept. No. 7508-	Rock Name	Biotite	Musco-vite	Tremo-lite	Quartz	Plagioclase	Microcline	Accessory Minerals
0141	Intensely sheared (?) monzogranite	Trace *	-	-	40	30 **	30	Se, Chl (5)
0142	Recrystallized sheared (?) tonalite	20 (Bt+Chl)**	-	-	20	60 *	Trace (?)	Ap, Op
0154	Sheared biotite (?) monzogranite	5	-	-	40	←(? albite)-55--?--→		Zr, Ap, Sph
0155	Foliated tremolite-albite rock	Trace	-	4	←-?--93	—(albite)→	-	Zr, Ap, Op (3), Sph
0165	Intensely sheared (?) granodiorite	-	-	-	40	50	10	Ap, Chl
0166	Fine-grained pelitic biotite-muscovite schist	28	7	-	←-?--65 (mainly (?) albite)--→			Op, Ep (?)
0177	Foliated tremolite-albite rock	Trace x	-	10	-	90 (albite)	-	Ap, Op, Sph
0178	Cataclastic arkosic psammite (?)	-	-	-	50	50	-	Zr, Se, Ru (?)
0185	Muscovite-bearing ribbon quartzite	Trace	7	-	93	Trace*	Trace	Zr, Ap, Op
0186	Recrystallized sheared porphyritic (?) syenogranite (?)	←---- 5 ---→		-	40	20	40 (s)	Op, Sph
0187	Foliated tremolite-biotite-albite-quartz rock	3	-	3x**	25	65 (albite)	-	Zr, Ap, Op (4), Sph Cbt

See Appendix B for explanation of symbols used.

elongated parallel to the main foliation and considerably strained (0154, 0165, 0186). *Plagioclase* grains, largely albitic, are in places grouped into patches and thus may have been derived fom original phenocrysts or porphyroblasts (0141, 0142). Earlier stages of intense fracturing of large crystals are well displayed in 0154 and 0165. Some fractures in 0165 are marked by a mosaic of quartz and/or microcline. The feldspar ranges from almost fresh (0165) to highly sericitized (0141). *Microcline* is found both as porphyroclasts (0141, 0186), some of which are strongly perthitic, and as fine grains in the matrix (0186).

Accessory minerals include zircon, apatite, sphene, opaque ores, muscovite and alteration products such as chlorite and sericite.

Grain boundaries tend to be highly irregular or sutured. There is little evidence for late annealing, except in 0142 where a granoblastic texture is locally developed. This recrystallization may account for the intense alteration affecting 0142.

The three thin sections from the pseudoconglomerate contain 3 to 10 percent *tremolite*, altered and randomly (0178) to moderately well (0177) oriented; the largest grains (l.5 cm long) are bent, crushed and/or strained (0187, 0155). The very fine grained groundmass consists largely of twinned and untwinned *albite* slightly elongated parallel to the main foliation. *Quartz*, present only in 0187, displays a mortar texture with sutured interquartz boundaries. *Accessory minerals* are zircon, apatite, opaque ore (up to 4 percent), sphene, carbonate and biotite (weakly to well oriented, dichroic in very pale shades of yellow and brown).

Three rocks of probable sedimentary origin were examined. A fine-grained pelitic biotite-muscovite schist (0166) contains 28 percent well-oriented flakes of *biotite*, dichroic in pale shades of brown, and 7 percent fine *muscovite*, much of it interleaved with biotite. The remainder of the rock is composed predominantly of small equant grains of albitic(?) *plagioclase*. Section 0178 is a cataclastic arkosic psammite containing 50 percent *plagioclase*, the largest crystals of which are highly fractured, and 50 percent *quartz* as ribboned grains in several narrow zones and elsewhere as small equant considerably recrystallized grains. *Accessory minerals* are zircon, sericite and possible rutile. Section 0185 is muscovite-bearing ribbon quartzite containing 7 percent well-oriented small flakes of *muscovite* and 93 percent *quartz*. The quartz grains, ribboned throughout the slide, are highly strained and have sutured intergranular margins. Early muscovite-free quartz veins with marginal chlorite have been affected in the same way. *Accessory minerals* include zircon, apatite, opaque ore grains, microcline and extremely pale brown biotite.

The junction between these mylonite rocks and the augen gneiss (Subunit 15b) to the southeast is abrupt and poorly exposed.

Biotite-Hornblende Granodioritic and Monzogranitic Augen Gneiss (Subunit 15b)

Augen gneiss characteristically occurs as a pink-weathering medium- or coarse-grained rock with an extremely well developed planar fabric defined by parallelism of quartz lenticles, mafic minerals (especially biotite) and feldspar porphyroclasts (predominantly microcline). Large idioblastic crystals of sphene, up to about 1 cm long, are abundant. This unit occupies some 85 km^2 of territory in the area. Thin section examination of eight specimens revealed that the augen gneiss is granodioritic or monzogranitic in composition (Table 15).

Biotite flakes 0.1 to 1 mm long are well oriented and generally dichroic from pale brown or straw yellow to moderate or dark brown (or rarely to moderate green (0175)). Alteration to chlorite is common (0152, 0160, 0175, 0315, 0316). Several crystals oriented at an angle to the dominant schistosity are present in 0189. Ragged poikiloblastic grains of *hornblende* up to 4 mm long, present in four sections (0167, 0189, 0315, 0316), are pleochroic in moderate shades of brown, brownish green and blue-green. Marginal alteration to epidote and/or biotite is typical.

Quartz tends to form small highly strained grains up to 0.5 mm in length (rarely to 1.5 mm) which have sutured margins and are greatly elongated in places, almost forming a ribbon texture (0188, 0315, 0316). *Plagioclase* (An_{20}) shows maximum extinction angles onto multiple twin planes of close to 0° and is present both in the groundmass and as large porphyroclasts up to 1.5 cm long. Some of these are fractured (0189, 0315), while others enclose quartz, biotite, apatite and patches of microcline. The mineral is slightly sericitized or saussuritized in half of the sections. *Microcline* forms groundmass grains and oriented porphyroclasts (2 cm). The porphyroclasts often show exsolution lamellae (string perthite) and enclose rounded grains of quartz and highly altered albite-rimmed subidioblastic grains of plagioclase. Some are considerably fractured and have highly irregular margins.

Sphene is an ubiquitous *accesory mineral*, forming large (2 mm) idioblastic and smaller xenoblastic grains. Zircon is abundant with most grains showing multiple zoning. Apatite forms rather large (up to 0.5 mm) clear subidioblastic to idioblastic grains. Opaque ore minerals are xenoblastic to subidioblastic and in some cases rimmed idioblastically by sphene (0175) or epidote. Yellowish amorphous patches, possibly allanite, are present in some sections.

Xenoblastic to subgranoblastic textures are locally developed (0175, 0316). Small amounts of myrmekite are common.

Within the augen gneiss, several lenses of earlier mafic gabbroic (possibly ranging to dioritic) amphibole gneiss (Subunit 15a) are cut by foliated granitoid rock genetically related to the augen gneiss.

Metagabbro/Metadiorite (Subunit 15a)

The lenses of metagabbro/metadiorite are generally 100 to 200 m wide (can be up to 600 m) and are continuous along strike for up to 10 km. Veins of foliated granitoid material containing feldspar megacrysts usually form at least 40 percent of the rock.

Table 15. Modal compositions of biotite ± hornblende granodioritic and monzogranitic augen gneiss (Subunit 15b) of the Needle Falls Shear Zone

Dept. 7508-	No.	Rock Name	Biotite	Musco-vite	Horn-blende	Sphene	Epidote	Quartz	Plagioclase	Micro-cline	Accessory Minerals
0152		Sheared biotite monzogranite	10**	-	-	Trace	-	30	30(oligoclase)*	30(s)	Zr, Ap, Op, Al
0160		Sheared biotite granodiorite	12 *	-	-	Trace	3	20	45(oligoclase)	20(s)	Zr, Ap, Op, Chl
0167		Sheared biotite-hornblende granodiorite	15	-	5*	Trace	Trace	25	40(oligoclase)	15(s)	Zr, Ap, Op
0175		Sheared biotite monzogranite	12 *	-	-	Trace	5	27	30(oligoclase)*	33	Zr, Ap, Op (3), Chl, Al
0188		Sheared biotite granodiorite	15	-	-	2	Trace	23	50(oligoclase)	20	Zr, Ap, Op
0189		Sheared biotite-hornblende monzogranite	9 x	-	1	1	Trace	20	28(oligoclase)	40(s)	Zr, Ap(1), Op, Al
0315		Sheared biotite-hornblende leucogranodiorite	3 *	Trace	Trace	Trace	Trace	36	47(oligoclase)*	14	Ap, Op
0316		Sheared biotite-hornblende leucogranodiorite	3 *	-	1*	Trace	-	36	41(oligoclase)*	20	Zr, Ap, Op

See Appendix B for explanation of symbols used.

Five rock samples collected from within lenses were examined (Table 16); four are from the early mafic phase and one represents the granitoid material. The latter (0228) is a leucomonzogranite containing well-aligned chloritized *biotite* crystals about 0.1 mm in length; *muscovite*; considerably flattened *quartz* grains (0.3 mm by 0.05 mm); strained *plagioclase*; and perthitic *microcline* grains up to 4 mm long. *Accesory minerals* are subidioblastic opaque ore, apatite, zircon, sphene, chlorite and epidote. Intergranular boundaries are irregular.

In the mafic rocks *hornblende* forms ragged randomly (0159, 0161) to well (0226, 0227) oriented crystals which are 1 to 2 mm long and pleochroic in pale to moderate shades of brown and moderate shades of blue-green. The mineral poikiloblastically encloses plagioclase and is variably altered at grain margins to epidote (0161), biotite, zoisite and chlorite (0226). *Biotite*, dichroic from pale to moderate brown, is an alteration product, together with epidote (where present), of hornblende. Flakes range up to 0.5 mm in length and are preferentially oriented (0159, 0227).

Quartz is moderately abundant in only one slide (0159) where it forms small, irregularly shaped, highly strained grains. *Plagioclase* (labradorite in 0226, 0227) is generally slightly altered to sericite or saussurite. Grains 0.1 to 4 mm across show normal zoning and in some places bent twin lamellae. They are strained, have a rounded outline and enclose biotite and apatite. *Microcline* is found only in a vein (0161) where it is associated with equant quartz and plagioclase.

Apatite is an ubiquitous *accessory mineral*; zircon and opaque ore are common. Sphene, sericite, epidote, zoisite, chlorite and carbonate are present in one or more sections.

Granitoid rocks cropping out in the vicinity of metagabbroic lenses contain amphibole.

Rottenstone Domain

Almost 85 percent or about 3000 km^2 of the area is underlain by rocks of the Rottenstone Domain. Of the seven major lithologic units recognized, granodioritic and monzogranitic rocks of the Wathaman Batholith (Unit 14) underlie by far the greatest area (1800 km^2), occupying the northwestern part of the domain. To the southeast are rocks of the migmatite (Unit 10) and tonalite/trondhjemite (Unit 11) complex. The migmatite with a total area of 460 km^2 is slightly less abundant than tonalite/trondhjemite (490 km^2). Lenses of the migmatite have been recognized in the Wathaman Batholith where they are usually in close spatial relationship with leucomonzogranites and leucosyenogranites (Unit 12).

Throughout the Rottenstone Domain, Units 10 to 14 do not possess characteristic weathering or erosional patterns and boundaries are ill-defined thus making airphoto interpretation difficult. The exception is the diabase (Unit 16) which can be broadly recognized by smooth erosional surfaces and a distinctive vegetation cover.

The age of the diabase (Unit 16) and of the impact melt rocks and breccias (Unit 17, Subunit 17a) on Calder Island, Gow Lake are unknown. Scott (1973) has suggested a possible Helikian age for the diabase, Robertson and Grieve (1975) an age of less than 600 Ma for the impact rocks.

Aeromagnetic patterns broadly separate the Wathaman Batholith which has variable magnetic intensities of 3600 to 4300 gammas from the migmatite-tonalite/trondhjemite complex which is magnetically uniform with intensities of 3300 to 3600 gammas. Diabase (Unit 16) in the vicinity of Tremblay Lake has produced strong but inconsistent aeromagnetic fluctuations.

Table 16. Modal compositions of metagabbroic/metadioritic lenses (Subunit 15a) within augen gneiss (Subunit 15b) of the Needle Falls Shear Zone

Dept. No. 7508-	Rock Name	Biotite	Hornblende	Epidote	Quartz	Plagioclase	Microcline	Accessory Minerals
0159	Foliated hornblende-biotite metaquartz gabbro (?)	10	35x	-	5-10	40-45*	-	Ap, Op, Sph, Se
0161	Hornblende-biotite metagabbro : groundmass	5	40x*	5	Trace	50*	-	Zr, Ap, Sph
	vein	-	-	-	40	20	40	
0226	Foliated hornblende-biotite metagabbro	5	40 *	Trace	Trace (in veins)	55(An_{58})**	-	Ap, Op, Zo(?), Chl
0227	Foliated biotite-hornblende metagabbro	25	25	-	Trace	46(An_{60})	-	Zr, Ap(1), Op(3), Cbt
0228	Sheared biotite leucomonzogranite	4 x**	-	Trace	25	25*	45(s)	Zr, Ap, Op, Sph, Ms(1), Chl

See Appendix B for explanation of symbols used.

Migmatitic Gneisses (Unit 10)

This rock unit comprises gneisses containing over 30 percent paleosome, which occur either as bands or schlieren 1 to 25 cm wide and alternating with foliated granitoid neosome (banded migmatite), or as rotated blocks within more massive neosome (agmatitic migmatite). The neosome is compositionally variable from tonalite to monzogranite. Within rafts of migmatite in the Wathaman Batholith, it consists of monzogranite or granodiorite with 10 to 37 percent microcline, whereas in the migmatite complex it generally contains less and more irregularly distributed microcline.

For descriptive purposes, samples of paleosome have been categorized into four subdivisions:

(a) Psammitic, semipelitic and pelitic biotite gneisses: In hand specimen these rocks are well foliated, fine or medium grained and pale pink (0061) or white (0029) to moderate grey (0277). Nine thin sections have been examined (Table 17).

Biotite occurs as well-aligned flakes 0.1 to 2 mm long and is dichroic in shades of brown or reddish brown (0235, 0245, 0250). Pleochroic haloes are moderately (0245, 0277) to very (0235) abundant. Where folds deforming the main schistosity are present (0063, 0245), biotite is parallel to the axial planes of the microfolds. Rare flakes are oriented oblique to the main schistosity (0100, 0235, 0277). There is little alteration to chlorite (locally in 0250).

Quartz is present as weakly strained, equant or slightly elongated (0063, 0100, 0235, 0277) grains up to 2 mm long. *Plagioclase* (An_{20-31}) shows grains without multiple twinning in some sections (0029, 0061, 0100, 0235, 0245) and variable alteration from fresh (0029, 0061) to moderately sericitized (0245, 0250). Grain size is mostly 1 to 2 mm but can be up to 4 mm. *Microcline* is of similar size to plagioclase and encloses quartz and altered plagioclase.

Accessory minerals are predominantly zircon (some with multiple zoning in 0235, 0250), apatite, opaque ore and muscovite, the latter two intimately associated with biotite.

Textures vary from xenoblastic to subgranoblastic. Myrmekite is present in several microcline-bearing slides (0235, 0245).

(b) Psammitic, semipelitic and pelitic biotite schists and gneisses containing garnet and/or sillimanite: In hand specimen these are generally mesotype coarse-grained well-foliated rocks containing wine red garnets 1 to 5 mm across and pearly sillimanite-rich lenticles. Nine thin sections have been examined (Table 18).

Biotite occurs as grains 0.5 to 3 mm in size and is dichroic in shades of brown or rarely red-brown. Colours change to pale green in the vicinity of garnets in section 0014. Alteration is uncommon, as are obliquely oriented flakes (only in 0214). Pleochroic haloes, moderately abundant, are numerous in section 0068. *Garnet*, present in all except one section (0013), occurs as xenoblastic to idioblastic fractured grains with a very spongy texture. It encloses rounded quartz blebs and more rarely biotite. An ill-defined enclosed planar fabric was observed only in section 0058. There is little evidence of retrograde metamorphism or late alteration.

Fibrous *sillimanite*, where folded (0013), has deformed by buckling and fracturing in contrast to

Table 17. Modal compositions of psammitic, semipelitic and pelitic biotite gneisses from migmatitic horizons (Unit 10) in the Rottenstone Domain

Dept. No. 7508-	Rock Name	Biotite	Muscovite	Quartz	Plagioclase	Microcline	Accessory Minerals
0029	Psammitic biotite gneiss	5	-	45	50	-	-
0061	Psammitic biotite gneiss	7	Trace x	35	40	15	Zr
0062	Psammitic biotite gneiss	10(+Op)	Trace	35	55*	-	Zr, Ap
0063	Folded semipelitic biotite gneiss	10-15 +	-	30	55-60*	-	Zr, Op
0100	Semipelitic biotite gneiss	20 x	Trace	25	55*	-	Zr, Ap
0235	Semipelitic biotite gneiss	12 x	Trace	40	45(An_{22})(ap)*	3	Zr
0245	Pelitic biotite gneiss	30	-	10	33(An_{20})**	27	Zr, Ap, Op
0250	Semipelitic biotite gneiss	13 *	-	27	30**	30	Zr, Ap, Op, Chl
0277	Semipelitic biotite gneiss	23 x	-	32	45(An_{31})*	-	Zr, Ap, Op

See Appendix B for explanation of symbols used.

Table 18. Modal compositions of psammitic, semipelitic and pelitic biotite schists and gneisses containing garnet and/or sillimanite, from migmatitic horizons (Unit 10) in the Rottenstone Domain

Dept. No. 7508-	Rock Name	Biotite	Muscovite	Garnet	Sillimanite	Quartz	Plagioclase	Microcline	Accessory Minerals
0012	Semipelitic biotite-garnet-sillimanite gneiss	12	-	← ≈ — 3 →		35	50	Trace ?	Zr, Op
0013	Folded semipelitic biotite-sillimanite gneiss	15	-	-	Trace	40	45	-	Zr
0014	Psammitic biotite-garnet gneiss	8	-	Trace ≈	-	32	60	-	Zr, Ap
0026	Semipelitic biotite-garnet gneiss	12	-	1	-	22	65	-	Zr, Ap, Op
0047	Semipelitic biotite-garnet gneiss	18	-	2 ≈	-	30	50*	-	Zr, Ap, Op, Sph
0058	Semipelitic biotite-garnet gneiss	15-20	-	5 ≈	-	20 ≈	55-60 ≈	-	Zr
0060	Psammitic biotite-garnet gneiss	5	-	3 ≈	-	40 ≈	52	-	-
0068	Pelitic biotite-garnet-sillimanite schist	35*	Trace x	Trace	Trace	-	65 *	-	Zr, Ap, Se, Chl
0214	Pelitic biotite-garnet-sillimanite gneiss	25 x	-	5 ≈	5	25	25(An_{27})	15	Zr, Ap, Op, Sph

See Appendix B for explanation of symbols used.

Table 19. Modal compositions of amphibole-biotite schists and gneisses (amphibole:biotite ratio ≤ 3:1) from migmatitic horizons (Unit 10) in the Rottenstone Domain

Dept. No. 7508-	Rock Name	Biotite	Amphibole	Garnet	Quartz	Plagioclase	Microcline	Accessory Minerals
0009	Weakly foliated biotite-actinolite metadiorite (?)	25 ≈	25(Act)	-	5	45	-	Zr, Ap
0011	Actinolite-biotite schist	15 x	35(Act)	-	10	40	-	Op
0015	Biotite-actinolite-garnet gneiss	20 x	15(Act)	Trace ≈	25	40	-	Ap, Op, Sph
0031	Hornblende-garnet-biotite gneiss	3 x	9(Hb)	8 ≈	35	45	-	Ap, Op, Chl
0059	Biotite-hornblende gneiss	← 10 →		-	20	70	-	Ap, Op, Ep
0065	Actinolite-biotite gneiss	3	7(Act)	-	25	55-60*	5-10	-
0256	Foliated hornblende-biotite metadiorite	12*	18(Hb) *	-	-	63(An_{38})*	-	Ap(2), Op(5), Chl, Cbt
0260	Foliated biotite-hornblende metadiorite	15	10(Hb)	-	2	70(An_{45})	-	Zr, Ap(2), Op(1), Sph

See Appendix B for explanation of symbols used.

the associated mimetically recrystallized biotite. Elsewhere it is contorted, apparently as a growth habit (in 0214 it is overgrown by biotite).

Felsic minerals are mainly represented by *quartz* and *plagioclase* (An_{25-30}). Some plagioclase grains are zoned (0012, 0014, 0026, 0068), others show slightly bent twin lamellae (0014, 0026, 0047, 0058). *Microcline* has been identified in only two sections: in trace amounts in 0012, and up to about 15 percent in 0214 where it forms both interstitial and large untwinned fractured grains up to 3 mm across. The latter contain inclusions of quartz and plagioclase.

Zircon is the most commonly occurring *accessory mineral.*

Intergranular boundaries are irregular in most sections (0012, 0060, 0068, 0214), but straight with triple-point junctions in a few (0014, 0026, 0047). There is slight alteration of biotite and plagioclase in two sections (0047, 0068); all others are unaltered.

(c) Amphibole-biotite schists and gneisses (amphibole:biotite ratio ≤ 3): In hand specimen these rocks are usually mesotype, fine to medium grained and well foliated, and occasionally contain garnet and disseminated sulphides. Eight specimens were examined in thin section (Table 19).

Amphibole appears to be hornblendic in some sections (0031, 0059, 0256, 0260), actinolitic in others (0009, 0011, 0015, 0065).[1] Good preferred orientation was noted (0011, 0031). Crystals are

[1]Distinction between the two types of amphibole has been largely based upon their pleochroic colours. Hornblende is in pale to moderate shades of brown and moderate to dark shades of green, olive green and/or blue-green; actinolite is in very pale shades of brown and green.

generally 1 to 2 mm long, in places poikiloblastically enclose quartz, plagioclase and/or apatite, and are intergrown with biotite. *Biotite* is generally well oriented, but some sections show sharply cross-cutting flakes (0011, 0015, 0031). Flakes vary in size from 0.5 to 2 mm. Dichroic colours are from pale to dark shades of brown; red tinges occur in only one section (0011). *Garnet* where present forms xenoblastic to idioblastic crystals whichhave a notably spongy texture and enclose mainly quartz. The incorporated phases show a slightly rotated included foliation in 0015.

Quartz and *plagioclase* (An_{25-45}) are the main felsic phases; quartz is markedly less abundant than it is in subdivision (b), while there is an increase in plagioclase, which tends to be calcic (usually andesine). Compositional zoning is widespread (0009, 0015, 0256). The overall size range is 0.5 to 4 mm, with larger grains containing rounded quartz blebs and amphibole. Twin lamellae are slightly curved (0009). *Microcline*, seen only in section 0065, occurs as interstitial material.

Apatite and opaque ore are present as *accesory minerals* in the majority of sections. Others include zircon, sphene, epidote, chlorite and carbonate.

Textures range from xenoblastic (0009, 0011, 0065) to granoblastic (0015, 0031, 0256, 0260). Alteration is rare, with minor sericitization of plagioclase (0065, 0256) and chloritization of biotite and amphibole (0256).

(d) Amphibole ± diopside ± biotite schists and gneisses (amphibole:biotite ratio generally ≤ 3): A wide variety of rocks has been included in this category, ranging from very coarse grained massive melanocratic metapyroxenite (0257), metameladiorite and metaquartz diorite (0278), to medium-grained melanocratic well-foliated hornblende schist (0069), to fine- to medium-grained pale greenish grey diopside-hornblende gneiss. Nineteen thin sections were examined (Table 20).

Amphibole is represented about equally by hornblende and actinolite. Grain size ranges from 0.1 to 0.5 mm (0253) up to 1.2 cm (0257). Random mineral orientation is typical of these rocks which are considered to be of probable igneous intrusive origin. However, many specimens especially those of diopside-bearing gneiss show at least some degree of preferred mineral orientation (0062, 0083, 0212, 0242, 0247, 0248, 0253), commonly of amphibole. Crystals are generally xenoblastic but some are subidioblastic. They poikiloblastically enclose rounded blebs of quartz, plagioclase, apatite and opaque ore; pleochroic haloes usually surround included grains of sphene. In section 0242 hornblende is concentrated into bands and actinolite is present as an alteration product of clinopyroxene.

Table 20. Modal compositions of amphibole ± diopside ± biotite schists and gneisses (amphibole:biotite ratio generally > 3) from migmatitic horizons (Unit 10) in the Rottenstone Domain

Dept. No. 7508-	Rock Name	Biotite	Amphibole	Pyroxene (Diopside)	Garnet	Quartz	Plagioclase	Accessory Minerals
0028	Hornblende gneiss	-	15(Hb) x *	-	-	50	35	Op, Sph, Chl
0037	Massive hornblende-biotite meta-meladiorite (?)	5x	55(Hb) x	-	-	Trace	40	Zr, Ap, Op
0057	Weakly foliated hornblende metadiorite (?)	Trace	25(Hb) x	-	-	-	75 *	Zr, Op
0062	Actinolite-biotite schist	3 x	30(Act)	-	-	Trace (in vein)	65 *	Ap, Sph, Ep
0062	Diopside-actinolite-biotite gneiss	5(+Op)	5(Tr/Act)	5	-	-	85	Sph, Ep
0069	Hornblende schist	-	85(Hb)	-	-	-	15 **	Zr, Ap, Op
0070	Biotite-hornblende-garnet-diopside gneiss	10	10(Hb)	Trace	Trace ?	20	60 *	Zr
0071	Hornblende gneiss	-	15(Hb)	-	-	30	52	Zr, Ap, Op(3), Al
0080	Massive actinolite-diopside meta-meladiorite	-	65(Act)	15 * (?)	-	-	20 **	-
0083	Hornblende-diopside-biotite gneiss	2 x	15(Hb)	10	-	-	70	Op(3)
0101	Diopside-hornblende-garnet gneiss	-	25(Hb)	30	Trace	5	40 *	Ap, Op, Sph, Se, Ep, Zo
0212	Diopside-actinolite gneiss	-	15(Act)	25	-	-	56(An_{76}) **	Op(2), Sph(2), Se, Cz
0242	Diopside-hornblende-actinolite gneiss	-	20(Hb,Act) *	35	-	Trace	40(An_{80}) *	Sph, Cbt, Zo(5)
0247	Diopside-hornblende gneiss	1	30(Hb?)	30	-	2	30(An_{72})	Ap, Op(4), Sph(3)
0248	Diopside-hornblende-garnet gneiss	-	16(Hb?) ≈	26 *	Trace	17	32(An_{90})	Ap(1), Op(3), Sph(5)
0253	Diopside-hornblende gneiss	-	25(Hb?)	38	-	5	25(An_{80}) *	Ap, Op(3), Sph(4), Se, Cbt
0257	Hornblende-diopside-biotite metapyroxenite	5*	65(Hb?) *	30 *	-	-	-	Ap, Op, Chl, Ep
0278	Metamorphosed actinolite-biotite mela-quartz diorite	10x	70(Act?)x	-	-	5	14(An_{35}) *	Zr, Ap, Op(2), Cbt
0282	Unfoliated hornblende-biotite diorite	3x	37(Hb)x	-	-	-	60(An_{38})	Ap, Op

See Appendix I for explanation of symbols used.

Underlined sample has been geochemically analyzed.

Diopside (0 to 30 percent) possesses a neutral colour and is subidioblastic to xenoblastic. Where present in the pale greenish grey gneisses (0062, 0070, 0083, 0101, 0212, 0242, 0247, 0248, 0253), diopside grains are small (0.2 to 1 mm long) and rarely show marginal alteration to hornblende (0248) or zoisite (0101, 0242). The clinopyroxene tends to be concentrated into bands which alternate with amphibole-rich bands. In massive metamelad[illegible]rite or metapyroxenite (0080, 0257), diopside is poikiloblastically enclosed within amphibole or plagioclase. In section 0257 the mineral is uralitized, schillerized and partially altered to epidote.

Biotite is a relatively insignificant mineral forming 0 to 10 percent of the rock. It is randomly oriented in meta-intrusive rocks (0037, 0278, 0282). Elsewhere it is well oriented (0070, 0247) or rarely sharply oblique to the foliation (0062, 0083). The mineral is dichroic in shades of pale yellow, brown and red-brown, and is both intergrown with (0070, 0278) and marginal to (0257, 0282) amphibole. Generally 0.5 to 2 mm long, it reaches lengths of 1 cm (0257) where it is extremely spongy and encloses amphibole and pyroxene. *Garnet* is present in trace amounts in sections 0070, 0101 and 0248.

Quartz (0 to 50 percent) is lacking or forms 5 percent or less of the rock. The exceptions are two specimens of hornblende gneiss (0028, 0071) and two specimens of pale greenish grey diopside-bearing gneiss (0070, 0248). The quartz grains are small to moderate in size with slight undulose extinction and rare elongation parallel to the main foliation. Grain margins are straight (0028, 0037) to irregular (0070, 0071, 0101) or rounded when enclosed as blebs within plagioclase or pyroxene (0248, 0253).

Plagioclase (0 to 85 percent) is of variable composition, grain size and degree of alteration. The most calcic type (labradorite, An_{72-90}) is from the pale green-grey diopside-bearing gneisses. Less calcic types (andesine, An_{35-38}) are from metamorphosed quartz dioritic and dioritic rocks (0278, 0282). Grain diameters are mostly less than 1 mm, but some are up to 3 mm. Sericitization is weak (0057, 0278) to intense (0062, 0070, 0080, 0101), especially close to veins (0062, 0070). Saussuritized grains also occur (0212, 0242, 0253). Very slight normal zoning is present in many grains in sections 0028, 0037, 0057, 0080, 0247, 0253 and 0282. Elongation parallel to the main schistosity is rare (0071, 0083, 0212).

Opaque ore is the most common *accessory mineral*. Granular to idioblastic sphene (to 5 percent), particularly abundant in the pale greenish grey diopside-bearing gneisses, is 0.1 to 0.3 mm across; it also occurs as complete or partial rims around opaque ore minerals. Apatite and zircon are also common. Epidote, zoisite, clinozoisite, allanite, chlorite, sericite and carbonate are present in a few sections largely as alteration products.

As with other migmatitic rocks, the textures vary from granoblastic and subgranoblastic to xenoblastic.

(e) Migmatite neosome: Neosome phases of migmatite contrast with paleosome phases in possessing higher microcline and muscovite contents and lower amphibole contents. They are leucocratic medium-grained massive to foliated rocks that form up to 70 percent of the migmatite (Unit 10).

Of fifteen thin sections examined (Table 21), five (0090, 0213, 0215, 0219, 0220) were of specimens collected from migmatite lenses in the Wathaman Batholith. The other ten specimens were collected from migmatite bands in the migmatite-tonalite/trondhjemite complex. Of these ten, six are tonalitic or trondhjemitic (with 0 to 5 percent microcline) and four are monzogranitic (with 27 to 30 percent microcline).

Biotite displays weak to good preferred orientation in about half the examined samples and random orientation in the remainder. It is weakly to highly altered to chlorite along cleavage planes. Flakes are generally from 0.5 to 3 mm long, most being about 1 mm. Dichroism is in shades of brown or reddish brown. Pleochroic haloes around included zircon or apatite are abundant in some sections (0213, 0215, 0244, 0249). *Muscovite* is mainly found marginal to or interleaved with biotite.

Quartz shows elongation parallel to the mica schistosity in seven sections. Grains are 0.5 to 4 mm in size (average 2 mm), variably fractured and usually highly strained. *Plagioclase*, the dominant constituent of most samples, is oligoclase-andesine in composition (An_{20-47}). Grains are similar in size to those of quartz and enclose biotite, apatite, rounded blebs of quartz and microcline. Twin lamellae are commonly bent (0090, 0209, 0219, 0220, 0262) and slight zoning is present sporadically (0215, 0244). Sericitization is present throughout in varying amounts. *Microcline* where present is interstitial (0087) as small grains less than 1 mm across, or forms fresh moderately sized grains 1 to 4 mm in diameter which enclose biotite, quartz and albite-rimmed sericitized plagioclase. Exsolution string perthite is rarely present (0213, 0244).

The main *accessory minerals* are garnet, sillimanite, zircon and apatite. Garnet crystals up to 2 mm are subidioblastic to idioblastic and contain few inclusions. Some show slight internal chloritization (0219, 0243) and rims of extremely pale brown phlogopitic mica. Sillimanite needles, not fibrolitic,

Table 21. Modal compositions of granitoid neosome from migmatitic horizons (Unit 10) in the Rottenstone Domain

Dept. No. 7508-	Rock Name	Biotite	Musco-vite	Amphi-bole	Garnet	Silli-manite	Quartz	Plagioclase	Microcline	Accessory Minerals
0087	Foliated biotite tonalite	12 *	Trace	-	-	-	25	58 *	5	Zr, Ap, Op
0088	Foliated biotite trondhjemite	8	-	-	-	-	20	72(oligoclase)**	-	Ap, Op, Ep, Al
0090	Sheared biotite monzogranite	5	Trace	-	-	-	20	40	35	Zr, Ap, Sph
0125	Foliated biotite-muscovite monzogranite	10*	2	-	-	-	35	25 *	28	Zr, Ap, Chl
0208	Foliated biotite trondhjemite	7	Trace	-	-	-	30	63(oligoclase)*	Trace	Zr, Ap, Cbt
0209	Foliated biotite monzogranite	5 ≈	Trace	-	-	-	25	40(oligoclase)*	30	Zr, Ap, Chl
0213	Foliated biotite-muscovite monzogranite	10	3	-	-	-	20	40(oligoclase)**	27(s)	Zr, Ap, Op, Ep
0215	Massive biotite granodiorite	10x*	Trace	-	-	-	30	50(oligoclase)*	10	Zr, Ap, Op
0219	Massive garnetiferous leuco-monzogranite	3x	Trace	-	Trace	-	27	33*	37	Zr, Op, Chl
0220	Massive biotite granodiorite	7x*	Trace	-	-	-	35	43(oligoclase)*	15	Zr, Ap, Op
0243	Massive garnetiferous trondhjemite	← 2 →		-	1	-	60	37(An_{23})**	-	Zr, Op
0244	Weakly foliated biotite monzogranite	5 ≈ x*	Trace	-	-	-	30	35(An_{20})*	30(s)	Zr, Ap, Op
0249	Sillimanite-bearing biotite-muscovite leucomonzogranite	5x	3x	-	-	1	30	34(An_{24})**	27	Zr, Ap
0262	Foliated biotite trondhjemite	8 **	-	-	-	-	37	51(An_{30})**	4	Zr, Ap, Op, Al, Chl, Cbt
0280	Massive hornblende-biotite tonalite	5x*	-	20(Hb?)x	-	-	25	50(An_{47})*	-	Zr, Ap, Chl

See Appendix B for explanation of symbols used.

Underlined samples were collected from rafts of migmatite in the Wathaman Batholith. All others were collected from migmatitic bands in the migmatite-tonalite/trondhjemite complex.

are well oriented and rimmed by muscovite or biotite (0249). Zircon is idioblastic to xenoblastic and locally shows normal (0220, 0249) or multiple zoning (0243, 0262). Apatite (up to 0.3 mm in diameter) is generally idioblastic.

Myrmekite is present in small or rarely large (0213, 0215, 0219) amounts in microcline-bearing rocks. Intergranular margins are irregular, although subgranoblastic textures have been noted (0249, 0280). Marginal breakup and recrystallization of mineral phases has occurred.

Biotite Tonalite/Trondhjemite (Unit 11)

This rock type is closely associated with the migmatitic gneisses in the southeastern portion of the Rottenstone Domain but contains less than 30 percent paleosomal material. To what extent the outcrop pattern is controlled by regional folding is not known: gneissose paleosome, in many places rotated, is contained within medium-grained whitish neosome which is itself foliated and folded.

Microcline is almost completely absent from this unit in the northeastern part of its outcrop area, extending from southern Deception Lake southwestwards to Begrand Lake. Farther southwest towards Kenyon Lake and Holmesa-Court Lake, however, microcline becomes an increasingly common component and rock types range from tonalite to monzogranite. Eighteen thin sections of the neosome were examined (Table 22). Of these, one has been classified as quartz diorite, seven as tonalites, five as trondhjemites, one as leucogranodiorite and the remaining four as monzogranites.

Biotite is weakly to well oriented in the majority of slides. However, random (0252, 0281) and oblique (0099, 0102, 0240, 0279) orientation are present. Dichroism is from pale yellow to dark brown or moderate reddish brown. Flakes are 0.5 to 2 mm in length. Pleochroic haloes are rare compared with the migmatitic unit. Chloritization affects biotite in 30 percent of the sections and is weak to strong, parallel to cleavages and associated with formation of rutile needles (0258). *Muscovite*, present in half the sections, is generally interleaved with and grows marginally upon biotite. *Amphibole* is represented about equally by actinolite/tremolite and hornblende.[1] Hornblende is altered in all sections to

[1]Actinolite/tremolite is almost colourless (0102) to pleochroic in very pale shades of green and brown (0091, 0099, 0312), whereas hornblende is pleochroic in moderate shades of brown, olive green and blue-green (0251, 0279, 0281).

Table 22. Modal compositions of predominantly foliated biotite tonalite/trondhjemite (Unit 11) in the Rottenstone Domain

Dept. No. 7508-	Rock Name	Biotite	Muscovite	Amphibole	Quartz	Plagioclase	Microcline	Accessory Minerals
0038	Foliated biotite trondhjemite	5‖ *	Trace	-	35‖	60‖*	Trace	Zr, Ap, Chl
0040	Foliated biotite trondhjemite	7‖	-	-	38‖	50 *	5	Zr, Ap
0041	Foliated biotite tonalite	10‖	Trace	-	20	70 *	Trace	Zr, Ap
0064	Foliated biotite trondhjemite	5‖	Trace	-	30‖	65 *	-	Ap, Op
0067	Weakly foliated biotite trondhjemite	7‖	Trace	-	35	58 *	-	Ap
0072	Weakly foliated biotite trondhjemite	7≈ *	Trace	-	30	63 *	-	Zr, Ap, Op
0091	Weakly foliated actinolite-biotite quartz diorite	8	-	17(Act)≈	10	65 *	-	Ap, Op
0092	Foliated biotite tonalite	10‖	Trace	-	[illegible]	60	-	Zr, Ap, Op
0093	Folded foliated biotite tonalite	10‖	-	-	30‖	60	-	Zr, Ap
0099	Foliated biotite-actinolite monzogranite	10‖ x	-	Trace (Act)	20	30	40	Zr, Ap, Sph
0102	Foliated biotite-tremolite tonalite	10‖ x	-	10(Tr?)	20	60 *	-	Zr, Ap, Op
0240	Foliated biotite tonalite	15‖ x	-	-	33‖	45(An_{28})*	4	Zr, Ap(1), Op(2), Ep
0251	Foliated biotite-hornblende monzogranite	7≈	Trace	Trace (Hb)**	33‖	30(An_{30})**	30	Zr, Ap, Op, Sph, Ep, Chl
0252	Biotite-muscovite leucogranodiorite	3x	1	-	30	46(An_{24})*	20	Zr, Ap or Si needles
0258	Weakly foliated biotite monzogranite	7‖ **	2	-	27‖	25(An_{28})**	39(s)	Ap, Op, Chl
0279	Foliated biotite-hornblende tonalite	12‖ x	-	2(Hb)*	26≈	55(An_{30})	5	Zr, Ap, Ep
0281	Hornblende-biotite monzogranite	3x*	-	5(Hb)x*	30	35(An_{30})*	27(s)	Zr, Ap, Op, Ep
0312	Weakly foliated biotite-actinolite tonalite	18≈	-	12(Act)x	20	50	-	Zr, Ap, Ep

See Appendix B for explanation of symbols used.

biotite, epidote, opaque ore and/or sphene. Preferred orientation is weak (0091) to absent (0281, 0312). The crystals are poorly shaped, 1 to 4 mm in size and most partially or wholly enclose quartz, biotite and/or plagioclase.

Quartz shows elongation parallel to the main mica orientation in seven of the sections. Grains are typically large (0.2 to 5 mm, most greater than 2 mm) and moderately strained and fractured. Later annealing appears to have affected quartz in section 0092. Quartz encloses plagioclase in sections 0062 and 0251. *Plagioclase* is generally upper oligoclase in composition (An_{24-30}). In places it shows preferred elongation (0038). Slight sericitization is typical and sometimes extensive (0251, 0258). Inclusions of quartz, biotite and zircon are common, and exsolved or replacement patches of microcline occur in some slides (0251, 0258, 0281). Grain size is in the range 0.5 to 3 mm, being generally 1 to 2 mm. Some crystals are strained, bent and/or fractured (0038, 0041, 0064, 0093, 0252) or weakly zoned (0041, 0072, 0091, 0093). Microcline is cross-hatched and fresh, and occurs interstitially or as subidioblastic grains over 5 mm long (0251, 0252, 0258) which enclose quartz, biotite, amphibole and altered albite-rimmed plagioclase. Some crystals are perthitic with exsolved spindles of plagioclase in central zones (0258, 0281).

The main *accesory minerals* are apatite and zircon. Apatite is idioblastic and is often included within biotite; crystals are up to 0.5 mm across and show cloudy cores in one section (0312). Zircon is multizoned in some sections (0279, 0281) and unzoned and idioblastic in others (0240, 0312). Section 0252 contains plagioclase crystals 1 cm long which are full of high-relief needles oriented parallel to the multiple twin planes; it is uncertain whether these are included sillimanite or apatite.

Xenoblastic textures are common. Myrmekite is present at microcline/plagioclase junctions in most microcline-bearing samples.

Xenoliths and rafts of country rock are commonly preserved within this tonalite/trondhjemite unit. They vary in diameter from several centimetres to a few hundred metres and are made up of a variety of rock types similar to that found in the migmatite (Unit 10).

Eight samples of the paleosome were examined in thin section. Three of these (0237 to 0239) were from the Rottenstone Mine and its immediate vicinity. The rock types and their estimated mineralogical compositions are listed in Table 23. Most show slight to extensive alteration particularly of plagioclase where present. The ultramafic host to the ore appears to be completely serpentinized (0238) and

its original character is therefore unknown. Xenoblastic garnet crystals ranging in size from 0.05 to more than 2 mm occur with sillimanite (enclosed within muscovite or associated with biotite) in sections 0237 and 0246.

Leucosyenogranite/Leucomonzogranite (Unit 12)

This rock type which covers about 80 km^2 is largely confined to the Wathaman Batholith within a few kilometres of its southeastern contact with the migmatite-tonalite/trondhjemite complex. It forms a discontinuous band extending from Pink Lake in the northeast through Hockley Lake to Taylor Creek in the southwest. Two lenses crop out within the migmatite-tonalite/trondhjemite complex; one is located south-southwest of Deighton Lake and the other extends from Lower Rottenstone Lake almost to Holmesa-Court Lake. These rocks almost invariably show a close spatial relationship with garnet- and/or sillimanite-bearing semipelitic and pelitic biotite schists.

In hand specimen these rocks are white and usually coarse grained or rarely medium grained. Muscovite, wine red garnet and/or biotite are the main accessory minerals. Generally the rock is massive, but planar fabrics are locally well developed. Sixteen samples of leucosyenogranite and leucomonzogranite were examined in thin section (Table 24).

Biotite is weakly to randomly oriented and dichroic from pale to moderate brown or rarely from pale straw yellow to moderate red-brown (0197, 0198) and pale brown to pale green (0261). Pleochroic haloes are often present and are very abundant in sections 0197, 0198, 0216 and 0217. Chloritization, ranging from partial to almost complete, has affected the mineral in about 25 percent of the sections. Flakes are up to 3 mm long but generally less than 1 mm. Folding and fracturing of biotite is seen in section 0198. *Muscovite* is intergrown with and overgrows biotite. It shows some degree of preferred orientation, generally very weak, in about 50 percent of the samples. The mineral has an extremely pale brownish tinge in plane-polarized light. Flakes are ragged and 1.5 to 3 mm long. *Garnet* crystals are typically small (less than 1 mm) but can reach diameters of 7 mm (0210). Xenoblastic or subidioblastic shapes are normal, but idioblastic grains occur in section 0211. Grains contain few quartz inclusions and are slightly cracked. Alteration is common as partial rims of mica (chlorite, biotite and/or muscovite in sections 0024, 0210, 0229, 0261, 0265) or as epidote along cracks (0034, 0046).

Quartz grains are very rarely elongated (0198, 0311); typically they are large (0.5 to 5 mm across, mostly about 2 mm), strained and fractured. *Plagioclase* is always distinctive in having almost straight extinction onto multiple twin planes (An_{20}). Sericitization is ubiquitous although generally weak. Crystals are large (1 to 5 mm), in places slightly zoned (0198, 0261) and contain inclusions of quartz, biotite and muscovite, and of microcline as exsolution patches (0216, 0217). Some grains have albitic margins (0211, 0216), while a few show bent twin lamellae (0229, 0261, 0265). *Microcline* forms small interstitial grains and large crystals 0.5 to 10 mm across (mostly 2 to 3 mm). The crystals very frequently exhibit exsolution of string-like lamellae and/or patches of albitic plagioclase, and enclose rounded quartz, sericitized albite-rimmed plagioclase, biotite and/or muscovite. Phenocrysts of Carlsbad-twinned cross-hatched microcline are common.

The main *accesory minerals* are zircon, apatite, opaque ore and sillimanite. Zircon is generally

Table 23. Modal compositions of rocks forming rafts within predominantly foliated biotite tonalite/trondhjemite (Unit 11) in the Rottenstone Domain

Dept. No. 7508-	Rock Name	Biotite	Muscovite	Amphibole	Pyroxene (Diopside)	Garnet	Silli-manite	Quartz	Plagioclase	Micro-cline	Accessory Minerals
0123	Gneissose metagabbro	-	-	5(Act)	30(+Ep)**	-	-	Trace (in vein)	65**	-	Op, Sph
0124	Metamorphosed leuco-quartz gabbro	Trace	-	15(Hb)**	3**	-	-	15	67**	-	Zr, Ap, Op, Sph, Chl, Cbt
0234	Pyritiferous semipelitic biotite gneiss	15	-	-	-	-	-	33	47(An_{30})	-	Op(5), Zr, Ap, Sph
0237	Pelitic biotite-sillimanite-garnet gneiss	25 **	Trace	-	-	3	5	5	62 (oligoclase)**	Trace	Zr, Ap, Op
0238	Mineralized serpentinized ultramafic	-	-	-	-	-	-	-	-	-	Op(30), Ant(70), Cbt in veins
0239	Tremolite-biotite rock	37x	-	55(Tr)x	-	-	-	-	-	-	Op(8), Ap, Cbt
0241	Hornblende-biotite gneiss	15 x	-	25(Hb)	-	-	-	15	45(An_{38})*	-	Zr, Ap, Op
0246	Semipelitic biotite-muscovite-garnet gneiss	15 x	2x	-	-	1	Trace	25	42(An_{29})*	15	Zr, Ap, Op

See Appendix B for explanation of symbols used.

Table 24. Modal compositions of massive to foliated leucosyenogranite or leucomonzogranite (Unit 12) in the Rottenstone Domain

Dept. No. 7508-	Rock Name	Biotite	Muscovite	Garnet	Quartz	Plagioclase	Microcline	Accessory Minerals
0024	Foliated biotite-muscovite-garnet leucomonzogranite	1‖	1‖	Trace ϕ	35	33*	30	Zr, Op, Chl
0034	Weakly foliated biotite-muscovite-garnet leucosyenogranite	1≈	1≈	1* ϕ	30	22*	45	Ep
0045	Biotite-muscovite-garnet leucomonzogranite	1.5	0.5	Trace ϕ	20	33*	45	-
0046	Garnet-biotite-muscovite leucosyenogranite	0.5	0.5	1* ϕ	20	8*	70(s)	-
0051	Weakly foliated biotite-muscovite leucomonzogranite	2.5≈	2.5x	-	25	25*	45	Zr, Ap, Op
0197	Massive biotite-muscovite leucosyenogranite	2x	2x		35	20(oligoclase)**	41(s)	Zr, Ap, Op
0198	Weakly foliated biotite-muscovite leucomonzogranite	4≈*	1	-	35≈	35(oligoclase)**	25(s)	Zr, Op, Sph
0210	Weakly foliated muscovite-biotite-garnet leucosyenogranite	1	2≈	Trace ϕ	27 ϕ	15(oligoclase)**	55(s)	Zr, Si(?)
0211	Foliated muscovite-garnet leucosyenogranite	Trace ≈	5‖	Trace ϕ	30 ϕ	20(oligoclase)*	45(s,p)	Op
0216	Weakly foliated muscovite-biotite leucosyenogranite	2x	5‖ x	-	30	20(oligoclase) (p)*	43(s,p)	Zr, Ap, Op, Chl
0217	Foliated biotite-muscovite leuco-quartz monzonite	4≈*	4≈	-	17	25(oligoclase)*	50(s,p)	Zr, Ap
0229	Massive muscovite-garnet leucomonzogranite	Trace**	1	Trace ϕ	25	38(An_{20})*	36(s)	Zr, Op, Si(?)
0259	Massive biotite-muscovite-garnet leucomonzogranite	3x*	2	Trace	20	33(An_{20})*	42	Zr, Op
0261	Massive garnetiferous leucomonzogranite	Trace x	Trace	Trace (rare inclusions) ϕ	35	38(An_{20})*	27(p)	Zr, Chl
0265	Sheared recrystallized garnetiferous leucomonzogranite	Trace	Trace	Trace (rare inclusions) ϕ	33	25*	42(s)	Zr, Op (dusty)
0311	Weakly foliated muscovite-biotite-garnet leucosyenogranite	2≈	4 ≈x	Trace ≈	35	15(An_{12})**	44	-

See Appendix I for explanation of symbols used.

idioblastic or sometimes rounded, up to 0.5 mm long and shows indications of multiple zoning (0216, 0229, 0265). Apatite forms rare well-shaped grains. Opaque ore is present in minute quantities generally as a dusty scattering. Sillimanite occurs in two sections (0210, 0229) as inclusions within quartz, microcline, plagioclase and/or garnet.

Intergranular boundaries between plagioclase and microcline are commonly marked by traces of myrmekite especially in sections 0210 and 0259. Marginal recrystallization with reduction of grain size affects many sections (0045, 0046, 0229, 0259, 0265). Elsewhere grain boundaries are extremely irregular in shape.

Biotite Tonalite/Trondhjemite to Biotite Syenogranite (Unit 13) of the Transition Zone

These rocks which have a highly variable microcline content form the transition zone between the microcline-rich monzogranitic and granodioritic rocks of the Wathaman Batholith and the microcline-poor rocks of the migmatite-tonalite/trondhjemite complex. They form two bands: the one in the northeast between Deception Lake and North Lake covers an area of about 130 km^2 and varies in width up to 6.3 km (averages about 2 km); the second, lying to the north, stretches from Pink Lake to west of Flatland Lake and is up to 2.5 km wide.

In both bands the rocks are typically well foliated, medium grained and equigranular, and vary from pale pink to white on fresh surfaces. They more closely resemble rocks of the tonalite/trondhjemite unit than those of the Wathaman Batholith. Lewry et al. (1980) stated that the Wathaman granitoids apparently intruded the white trondhjemite/tonalite of the migmatite belt to the east and that the contact is marked by a broad zone of alteration and potash metasomatism of the country rock. It seems that the contact in this map area is much the same as that described by Lewry et al. Within the dominantly massive Wathaman Batholith there are zones of foliated granitoid rocks, mostly grouped into Subunit 14b (sections 0230 to 0233), which are perhaps tonalites and trondhjemites transformed to granodiorite by microcline enrichment. In the area underlain by rocks of Unit 12 no intrusive relationships were observed between the various granitoids and a metasomatic source for the microcline is a distinct possibility.

Eleven thin sections of this unit have been petrographically examined (Table 25).

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Table 25. Modal compositions of foliated and massive rocks of intrusive origin and of highly variable microcline content from a transition zone (Unit 13) situated between the predominantly monzogranitic rocks of the Wathaman Batholith (Unit 14) and the migmatite (Unit 10) -tonalite/trondhjemite (Unit 11) complex, Rottenstone Domain

Dept. No. 7508-	Rock Name	Biotite	Muscovite	Garnet	Quartz	Plagioclase	Microcline	Accessory Minerals
0039	Massive biotite trondhjemite	7x	Trace	-	30	63*	-	Zr, Ap, Op
0043	Foliated biotite leuco-quartz monzonite	3	Trace	-	15‖	37**	45	Ap
0048	Foliated trondhjemite	5‖ *	1	-	40‖	50**	5	Zr, Ap
0066	Foliated leucogranodiorite	Trace	-	-	25‖	58*	17	Op, Sph
0075	Weakly foliated biotite leucogranodiorite	4 ≈	1 ≈	-	30	45(oligoclase)**	20	Op
0076	Foliated biotite tonalite	10‖	Trace	-	30‖	55*	5	Zr, Ap
0077	Massive biotite granodiorite	5x*	Trace	-	20	55(oligoclase)*	20	Zr, Ap, Op
0086	Weakly sheared biotite-garnet leuco-monzogranite	3	Trace	Trace ϕ*	22	30(oligoclase)*	45	-
0098	Massive garnet-biotite granodiorite	5x*	-	3 ϕ	27	50(oligoclase)	15	Zr, Op
0254	Foliated biotite syenogranite	7‖ x*	-	-	30‖	20(An_{24})*	43(s.p)	Zr, Ap, Op
0255	Foliated biotite granodiorite	6≈ *	Trace	-	28‖	45(An_{23})**	22	Zr, Op, Ep, Chl

See Appendix B for explanation of symbols used.

Biotite flakes 0.5 to 2 mm long are well to randomly oriented and typically dichroic from pale to dark brown. Chloritization has locally affected biotite in about half the rocks. *Muscovite* is intergrown with (0039) or marginal to (0255) biotite.

Quartz shows preferred dimensional orientation in about 50 percent of the sections; it invariably shows undulose extinction and varying intensities of fracturing. The grain size ranges from 0.5 to 2 mm and rarely to 5 mm. Larger grains show incipient mortar texture and sutured interquartz boundaries (0255). *Plagioclase* (An_{23-24}) is sericitized in every section to at least a slight degree. Warping of twin lamellae (0039, 0076, 0077, 0098, 0254, 0255), slight zoning (0075, 0077) and inclusions of rounded quartz blebs, biotite and patches of microcline (0075, 0076, 0254) are characteristic features of the mineral. Grain diameters of up to 5 mm are common. *Microcline* is present in all sections except 0039. Where it forms less than 10 percent of the rock (0048, 0076), it occurs as small interstitial grains. Elsewhere large grains up to 1 cm long enclose quartz, albite-rimmed altered plagioclase and subidioblastic biotite, and in one section (0254) exsolved patches and string-like lamellae of perthitic plagioclase.

Zircon, apatite and opaque ores are common *accessory minerals*; garnet and sphene are rare. Garnet is present in two sections (0086, 0098) as xenoblastic grains containing sparse inclusions of quartz; weak marginal alteration to pale green biotite is evident in section 0086. Epidote and chlorite occur as alteration products.

Apart from small amounts of myrmekite, intergranular boundaries are irregular or rarely sutured (0255). Boundary granulation occurs along specific planes transecting the rocks in sections 0039, 0043 and 0086.

Granitoid Rocks of the Wathaman Batholith (Unit 14, Subunits 14a to e)

Granitoid rocks of the Wathaman Batholith underlie about 1800 km^2 of the northwestern Rottenstone Domain. They cover a further 1600 km^2 in the Parker Lake-Nelson Lake area (Ray, 1980) and more than 350 km^2 in the Ghana Lake area (Lewry et al., 1980). Weber et al. (1975a) have described a batholith covering more than 1600 km^2 in Manitoba which appears to be similar to the Wathaman Batholith.

Rock types within the batholith are compositionally uniform making subdivision difficult. The most obvious distinction in the field is between megacrystic types in which feldspar megacrysts greater than 2 cm are common (Subunit 14a) and nonmegacrystic types. Weak to strong foliation is recognizable in many places (Subunit 14b). Rock types in this subunit tend to be less microcline rich. Amphibole, usually hornblende, is present locally (Subunit 14c) in an area northwest of Kellogg and Hockley Lakes. Muscovite is commonly present in trace amounts but forms several percent of the rock between Tremblay Lake and Kellogg and Hockley Lakes (Subunit 14d). Remnant lenses of metagabbro/metadiorite (Subunit 14e) injected by granitoid material crop out near the Needle Falls Shear Zone in the northwest. These various subdivisions grade into one another and boundaries

between them are generally indistinguishable on the present scale of mapping.

Planar fabrics within foliated granitoid rocks (Subunit 14b) result from 1) laminar flow during intrusion, 2) mimetically inherited fabric from pre-existing foliated rocks, and 3) deformation during or following granitoid emplacement. All three processes were probably active, but the second is considered most important as it most readily explains the slightly more basic average composition of this subunit and its apparent concentration into long, narrow and in places folded zones within the otherwise massive batholith. Ray (1980) favors the first and third processes as being the major causes.

A total of 70 samples of granitoid rock from Unit 14 and Subunits 14a to d have been petrographically examined (Tables 26 to 32). A summary of the modal variations is given in Table 33.

Biotite is dichroic, frequently from moderate to dark brown and rarely from pale straw yellow to moderate brown. The length of flakes varies from 0.2 to 3 mm but is normally 1 to 2 mm. Pleochroic haloes are sparsely developed around included zircon and euhedral apatite. *Muscovite* where present is usually intimately associated with biotite either as interleaved flakes or as minute marginal grains which are especially concentrated at terminations. *Amphibole* is generally ragged and 1 to 3 mm long. Marginal alteration to epidote, biotite and/or chlorite is characteristic. Grains poikilitically enclose quartz, apatite and plagioclase.

Quartz everywhere exhibits undulose extinction and is generally fractured. Crystals range from 0.4 to 5 mm but are commonly 1 to 3 mm. Some degree of dimensional orientation is present in a number of sections (0032, 0170, 0195, 0202, 0222, 0231, 0232, 0233, 0267). *Plagioclase*, subhedral in a few sections (0001, 0025, 0052), is oligoclase-andesine (mostly An_{20-30}) and almost always partially altered to sericite. Grain size can vary from 0.5 to 8 mm but is generally in the range 1 to 4 mm. Inclusions where developed are usually of quartz, biotite and rarely

Table 26. Modal compositions of Wathaman Batholith rocks which are generally monzogranitic to granodioritic in composition, massive and contain megacrysts < 2 cm long (Unit 14), Rottenstone Domain

Dept. No. 7508-	Rock Name	Biotite	Muscovite	Quartz	Plagioclase	Microcline	Accessory Minerals
0001	Massive biotite leucomonzogranite	4x*	-	35	28*	33	Ap, Op, Chl
0003	Massive biotite monzogranite	5x	-	35	35*	25	Zr, Ap, Op, Sph
0004	Weakly foliated biotite monzogranite	7≈	-	30	32(ap)*	30	Ap, Op, Sph(1), Chl
0006	Massive biotite leucosyenogranite	2x	Trace	25	20	53	Op
0025	Massive biotite leucomonzogranite	2x*	-	25	43*	30	Op
0032	Foliated biotite monzogranite	5‖	Trace	20‖	45	30	Zr, Op
0052	Massive biotite leuco-quartz diorite	12	-	5	83(ap)*	Trace	Zr, Ap
0053	Massive biotite granodiorite	5x*	-	20	50*	25	Zr, Ap, Op, Sph
0054	Massive biotite granodiorite	5x	Trace	35	45*	15	Zr, Op
0056	Massive biotite granodiorite	5x*	Trace	25	50*	20	Zr, Ap, Op
0078	Weakly foliated biotite monzogranite	5≈	Trace	35	35(oligoclase)*	25	-
0082	Massive biotite leucomonzogranite	2*	Trace	23	40*	35	Chl
0084	Massive biotite-garnet tonalite	10x	-	35	55(oligoclase)*	-	Zr, Ap, Gt
0151	Massive biotite leucomonzogranite	3x*	-	25	32**	40(s)	Zr, Ap, Op, Sph, To, Chl
0171	Massive biotite granodiorite	10x	Trace	35	40(oligoclase)	15	Zr, Ap, Op, Sph, Al
0199	Massive biotite leucomonzogranite	3x*	Trace	25	25(oligoclase) (ap)*	47(s)	Zr, Ap, Op, Chl
0202	Well-foliated biotite quartz monzonite	13	-	15≈	36(oligoclase/ andesine)	36(s,p)	Zr, Ap, Op, Sph, Al
0207	Massive biotite leucosyenogranite	2x*	Trace	30	20(oligoclase)*	48(s)	Ap, Op
0222	Foliated biotite leucomonzogranite	4	Trace	35‖	32(oligoclase)**	35	Zr, Ap, Op
0236	Massive leucogranodiorite	2x	Trace	40	48(An_{20})*	10	Zr
0263	Massive biotite leucomonzogranite	5*x	1x	30	25(An_{25})**	39(s)	Zr, Ap, Op, Chl
0266	Massive porphyritic biotite monzogranite	7x**	Trace	25	25(An_{25})**	43(s)	Zr, Ap, Op, Sph, Al, Chl

See Appendix B for explanation of symbols used.

Table 27. Modal compositions of Wathaman Batholith rocks which are generally monzogranitic, leuco-quartz monzonitic or granodioritic in composition, massive and contain megacrysts > 2 cm long (Subunit 14a), Rottenstone Domain

Dept. No. 7508-	Rock Name	Biotite	Muscovite	Quartz	Plagioclase	Micro-cline	Accessory Minerals
0005	Massive biotite monzogranite	7x	-	30	30	32	Ap, Op, Sph(1), Chl
0016	Massive biotite leucosyenogranite	3x	-	35	17*	45	Op
0017	Massive biotite monzogranite	8x*	-	25	25*	42	Zr, Ap, Op, Sph, Chl
0018	Massive biotite syenogranite	5x	-	30	15*	50	Ap, Op, Sph
0019	Massive biotite monzogranite	10x	-	25	25*	40	Zr, Ap, Op, Sph
0020	Massive biotite granodiorite	5x	-	25	50*	20	Zr, Ap, Op
0021	Massive biotite leucomonzogranite	2x*	Trace	33	32(an)	33	Ap, Ep
0022	Massive biotite leuco-quartz monzogranite	5**	-	15	35**	45	Ap, Op, Sph
0030	Weakly foliated porphyritic biotite leuco-quartz syenite	3*	-	17	20*	60	Zr, Ap, Op, Chl
0033	Weakly foliated porphyritic biotite granodiorite	5=	-	25	50*	20	Ap, Op
0035	Weakly foliated biotite granodiorite	5=	-	25	50*	20	Zr, Ap, Op, Ep
0036	Weakly foliated biotite monzogranite	5=	Trace	30	30*	35	Zr, Ap, Op
0081	Massive biotite granodiorite	5x	Trace	30	55*	15	Zr, Ap
0296	Massive porphyritic biotite monzogranite	10x*	Trace	20	35(oligoclase)*	35(s)	Zr, Ap, Op, Sph
0297	Massive porphyritic biotite leuco-quartz monzonite	8x	-	17	38(oligoclase)*	37	Zr, Ap, Op, Sph
0298	Massive porphyritic biotite leuco-quartz monzonite	5x*	Trace	17	33(oligoclase)*	45	Zr, Ap, Op, Sph, Ep
0299	Massive porphyritic biotit. monzogranite	5x*	-	23	33	39	Zr, Ap, Op, Sph
0300	Massive biotite granodiorite	10x*	Trace	35	38(oligoclase)*	17	Zr, Ap, Op, Chl
0301	Massive biotite granodiorite	10x*	Trace	30	40(oligoclase)*	20	Zr, Ap, Op, Chl
0302	Massive porphyritic biotite monzogranite	10x*	Trace	22	28(oligoclase)*	40	Zr, Ap, Op, Chl

See Appendix B for explanation of symbols used.

Underlined samples have been geochemically analyzed.

opaque ore, apatite, zircon and amphibole. Antiperthitic patches of microcline are oriented parallel to multiple twin lamellae (0232); elsewhere (0266) microcline appears to form replacement patches in plagioclase. Slight normal zoning and bending of twin lamellae is observed in some plagioclase grains. *Microcline* is variable in size, forming interstitial grains less than 1 mm across and/or megacrysts exceeding 1 cm in length. The larger grains, often Carlsbad twinned, contain rounded blebs of quartz, small sericitized albite-rimmed plagioclase and/or biotite and opaque ore (rare). String and patch microperthite is common.

The main *accessory minerals* are zircon, apatite, garnet, opaque ore and allanite. Zircon is present as small anhedral to euhedral crystals, in many cases zoned and in a few cases multizoned (0151, 0194, 0200, 0205, 0223, 0232). Apatite is ubiquitous and in some sections (0203, 0204) abundant; crystals are up to 1 mm long and usually euhedral. Garnet where present (0042, 0084) is anhedral to euhedral, contains few inclusions and is associated with pale green to pale brown biotite. Anhedral to subhedral opaque ore grains are widespread. Some are rimmed by sphene (0007, 0202, 0264, 0297) which also forms discrete crystals, occasionally euhedral (0005, 0296, 0313) but generally anhedral. Allanite is a common accessory, while tourmaline was found in one section (0151). The main alteration products are sericite, chlorite, epidote and carbonate.

Myrmekite is common in minor amounts. An equigranular xenomorphic texture is dominant; hypidiomorphic textures are rare. In places crystals appear to have broken up and recrystallized at their margins due to weak cataclasis (0030, 0032, 0082, 0084, 0264, 0266, 0267).

Xenoliths and rafts within the Wathaman Batholith are common. Rock types represented include metasediments such as psammitic biotite-muscovite-garnet-sillimanite gneiss and pelitic biotite gneiss, and those derived from intrusive rock such as foliated megacrystic granite. Foliation (schistosity and gneissosity) was imparted to the

Table 28. Modal compositions of Wathaman Batholith rocks which range from biotite monzogranite to biotite-actinolite quartz diorite in composition and are generally foliated (Subunit 14b), Rottenstone Domain

Dept. No. 7508-	Rock Name	Biotite	Muscovite	Hornblende (or Actinolite)	Quartz	Plagioclase	Microcline	Accessory Minerals
0002	Weakly foliated biotite monzogranite	5≈	-	-	25	30*	40	Ap, Op, Sph
0006	Foliated biotite-actinolite quartz diorite	23‖	-	22(Act)	5	50*	-	Zr, Ap, Sph
0007	Foliated biotite-hornblende quartz monzodiorite	10‖	-	10(Hb)	5	65	10	Zr, Ap, Op, Sph
0042	Massive biotite-garnet leucomonzogranite	1*	-	-	25	34*	40	Zr, Op, Gt
0049	Weakly foliated biotite leucomonzogranite	3≈	-	-	20	32*	45	Zr, Ap, Op
0050	Weakly foliated biotite tonalite	10≈	-	-	35	55*	-	Zr, Ap
0085	Weakly foliated biotite monzogranite	10≈*	-	-	30	30(oligoclase)*	30	Zr, Ap, Op
0168	Weakly foliated biotite-hornblende granodiorite	5≈	-	5(Hb)*	20	55(oligoclase)*	10	Ap, Op, Ep(5%)
0170	Foliated biotite-actinolite tonalite	10‖	-	5(Act)	30≈	55	-	Zr, Ap
0193	Weakly foliated biotite granodiorite	9≈	Trace	-	30	45(oligoclase)(ap)*	15(s)	Zr, Ap, Op(1%)
0195	Weakly foliated biotite tonalite	10≈	-	-	35≈	55(oligoclase)*	Trace	Zr, Ap, Op, Cbt
0200	Foliated biotite tonalite	12≈	-	Trace (Hb)	23	65(oligoclase)(ap)*	-	Zr, Ap, Op, Ep
0201	Massive biotite granodiorite	10x	Trace	-	28	47(oligoclase)*	15	Zr, Ap, Sph, Ep, Al
0230	Weakly foliated porphyritic biotite leucomonzogranite	4≈	-	-	25	46(An_{25})*	25(s)	Zr, Ap, Op
0231	Well-foliated biotite-hornblende granodiorite	10‖	-	Trace (Hb)*	30≈	48(An_{30})(ap)	12	Ap, Op, Ep
0232	Weakly foliated biotite granodiorite	10x	-	-	35‖	48(An_{28})*	7(s)	Zr, Op
0233	Foliated biotite-hornblende granodiorite	5‖x	Trace	2(Hb)**	30≈	45(An_{28})**	18	Zr, Ap, Op, Sph, Ep
0264	Foliated biotite-hornblende granodiorite	7‖x	-	3(Hb)*	25	45(An_{28})*	20(s,p)	Zr, Ap, Op, Sph, Ep
0267	Foliated biotite monzogranite	13‖	Trace	-	20‖	30(An_{23})	37(s,p)	Zr, Ap, Op, Sph
0313	Foliated biotite-hornblende monzogranite	10‖	-	Trace (Hb)	20	40(oligoclase)	30	Zr, Ap, Op, Sph, Ep

See Appendix B for explanation of symbols used.

Table 29. Modal compositions of Wathaman Batholith rocks which are generally biotite-hornblende granodiorite in composition and foliated to massive (Subunit 14c), Rottenstone Domain

Dept. No. 7508-	Rock Name	Biotite	Musco-vite	Horn-blende	Quartz	Plagioclase	Micro-cline	Accessory Minerals
0194	Massive biotite-hornblende tonalite	7x*	1	1**	30	58(andesine)(ap)*	3(s)	Zr, Ap, Op, Ep, Cbt, Chl
0196	Foliated biotite-hornblende granodiorite	5≈x*	Trace	1x*	30≈	50(oligoclase)(ap)	14(s)	Zr, Ap, Op, Sph
0203	Massive biotite granodiorite	10x*	1	-	33	41(ap)	15(s)	Zr, Ap, Op, Cbt, Chl
0204	Foliated biotite-hornblende granodiorite	8≈*	Trace	4≈*	33	40(oligoclase)(ap)*	15	Zr, Ap, Op, Sph, Ep, Chl
0205	Foliated biotite-hornblende granodiorite	6≈*	-	5*	20	55(oligoclase)(ap)*	14(s)	Zr, Ap, Op, Sph, Ep
0223	Weakly foliated biotite granodiorite	6≈	Trace	-	38	38(oligoclase)**	18(s)	Zr, Ap, Op, Ep, Chl, Al
0224	Foliated biotite-hornblende granodiorite	6‖	-	4*	20≈	60(ap)	10	Zr, Ap, Op

See Appendix B for explanation of symbols used.

xenoliths prior to emplacement of the batholith. The estimated modes of four samples from xenoliths are given in Table 32.

Amphibole-bearing rafts (Subunit 14e) are especially well preserved and are abundant westwards towards the Needle Falls Shear Zone where they reach dimensions of up to 350 m wide and 2.5 km long. They are crossed by dykes and veins of intrusive rocks similar to those forming the batholith. Two samples were examined in thin section. The first, a weakly foliated monzogranite (0169), is similar to

Table 30. Modal composition of a foliated to massive biotite-muscovite monzogranite (Subunit 14d), Rottenstone Domain

Dept. No. 7508-	Rock Name	Biotite	Musco-vite	Quartz	Plagioclase	Micro-cline	Accessory Minerals
0218	Foliated biotite-muscovite leucomonzogranite	7≈	3‖	20‖	35(oligoclase)*	35(s)	Zr, Ap

See Appendix B for explanation of symbols used.

Table 31. Modal compositions of rocks from lenses within the Wathaman Batholith which are predominantly metagabbroic/metadioritic in composition (Subunit 14e), Rottenstone Domain

Dept. No. 7508-	Rock Name	Biotite	Horn-blende	Quartz	Plagioclase	Micro-cline	Accessory Minerals
0169	Weakly foliated monzogranite	10≈	-	30	35(oligoclase)	25	Ap, Op, Sph
0206	Foliated biotite-hornblende diorite	20‖ **	20**	Trace	59(oligoclase)**	-	Ap(1≈), Op, Sph, Ep, Chl

See Appendix B for explanation of symbols used.

Table 32. Modal compositions of xenolithic material from various rock units within the Wathaman Batholith, Rottenstone Domain

Dept No. 7508-	Rock Name	Biotite	Musco-vite	Horn-blende	Garnet	Silli-manite	Quartz	Plagioclase	Microcline	Accessory Minerals
0023	Hornblende-biotite gneiss	2‖	-	23≈	-	-	Present in vein	75(present also in vein)	Present in vein	Op
0027	Hornblende gneiss	Trace	-	18‖	-	-	20‖	60	-	Ap, Op(2≈)
0055	Psammitic biotite-muscovite-garnet-sillimanite gneiss	⟵ 5≈ ⟶		-	Trace ϕ	Trace	45	50	-	Zr, Ap, Op
0225	Pelitic biotite gneiss	35‖ x*	Trace	-	-	-	15≈	27(oligoclase) (ap)*	23(s)	Zr, Ap, Op

See Appendix B for explanation of symbols used.

Table 33. Summary of modal variations in rocks of the Wathaman Batholith

Mineral	*Unit 14 (22 sections)*	*Subunit 14a (20 sections)*	*Subunit 14b (20 sections)*	*Subunit 14c (7 sections)*	*Subunit 14d (1 section)*
	Table 26	*Table 27*	*Table 28*	*Table 29*	*Table 30*
Biotite	2-13	2-10	1-13(23)	5-10	7
Muscovite	0-1	0-Trace	0-Trace	0-1	3
Hornblende	-	-	0-10(22)	0-5	-
Quartz	(5)15-40	15-35	(5)20-35	20-38	20
Plagioclase	20-55(83)	15-55	30-65	40-60	35
Microcline	(0)10-53	15-45	0-45	3-18	35

Percentages in parentheses are anomalous values

monzogranite from the batholith. The other, a foliated biotite-hornblende diorite (0206), consists of pale to moderate brown chloritized *biotite* flakes, fairly well oriented and up to 1 mm long; *hornblende*, pleochroic in moderate shades of green and blue-green and altered along fractures and around margins to chlorite and epidote; and sericitized *oligoclase*, some grains of which are weakly zoned and many grains of which are somewhat fractured parallel to the main schistosity. *Accessory minerals* are apatite (as prisms 1 to 2 mm long), euhedral sphene, opaque ore and strained grains of quartz.

Diabase (Unit 16)

Diabase occurs as sills, dykes and plugs largely situated within the Wathaman Batholith. No contacts with adjacent rocks were seen except in the case of a narrow (10 cm wide) fine-grained dyke (0044) parallel to a set of joints. It forms only rare exposures standing a few centimetres above the surrounding ground. However, rounded diabase boulders are common on ground underlain by this rock type. Jointing is variably developed but usually poor. In hand specimen the rock is massive, medium grained

and equigranular; subophitic textures are common on the greenish grey weathering surfaces.

In thin section (Table 34) the two dominant mineral phases are plagioclase and pyroxene. *Plagioclase* (approximately An_{50}) occurs as ragged, strongly zoned, interlocking laths, many of which are subophitically intergrown with a pale brown augite. The *pyroxene* shows marginal alteration (up to 10 percent of the mineral) to pale green/brown actinolitic amphibole and pale green chlorite. The main *accessory mineral* is apatite, which forms long acicular needles. Skeletal grains of an opaque ore mineral are present. Interstitial vermicular intergrowths of quartz and potassium feldspar are present in several sections (0010, 0089).

The narrow dyke (0044) consists of zoned (including oscillatory zoning) *plagioclase* (3 percent), as randomly oriented subhedral and euhedral laths up to 3 mm long, and subhedral pale brown augitic *pyroxene* (2 percent) in a groundmass of feldspar microliths which show a preferred orientation, probably a flow alignment, and abundant granular opaque ore which imparts a dark colour. Some grains of the pyroxene are apparently pseudomorphed by amorphous brown iddingsite or a chloritic mineral.

Impact Melt Rocks (Unit 17) and Impact Breccias (Subunit 17a)

A small area (approximately 0.5 km^2) on the northwest corner of Calder Island in the centre of Gow Lake is occupied by a hill composed of well-fractured, dark grey, fine-grained, siliceous lava-like rock (kärnäite). The surrounding lower ground is underlain by rubbly pale dun-weathering rock with a distinct pyroclastic appearance (suevite).

These rocks are unique in the map area and apparently in the Precambrian Shield of northern Saskatchewan. They have been mentioned by Robertson and Grieve (1975) and by Thomas and Innes (1977), who consider them to have undoubtedly been produced by meteor impact. Robertson and Grieve (1975, p.14) described the Gow Lake structure as:

> ... a deeply eroded, complex crater in Precambrian rocks. The roughly circular Gow Lake averages 5 km in diameter, has a central island, 1 by 2 km, and preliminary soundings indicate water depths of 25 to 35 m. A reconnaissance survey of the structure by Innes and Thomas (Earth Physics Branch) resulted in the discovery of breccias with low-grade shock features plus a small amount of impact melt in outcrop on the central island. Nineteen gravity stations on the island and mainland define a 2 milligal negative anomaly coincident with the lake. The Gow Lake structure is the smallest Canadian crater known to possess a central uplift, and may be close to the size at which the transition from simple to complex craters occurs on Earth in crystalline target rocks.

Two thin sections (0073, 0074) of the impact-produced rocks from Calder Island have been examined. The first of these (0073), composed of impact melt or kärnäite, is found to have a variable texture across the slide. The groundmass is composed of tiny (less than 0.1 mm long) randomly oriented laths of plagioclase set in an amorphous brown glassy matrix which shows perlitic fractures in places. The groundmass contains small flakes of very pale brown biotite and supports strained and fractured angular quartz grains, most of which have fine parallel striations in one or several directions. Quartz grains lacking planar features have been recrystallized under the thermal influence of the enclosing melt (Robertson, personal communication). Other quartz grains possess a mosaic of subconchoidal fractures interpreted by Thomas and Innes (1977) and by Robertson to be evidence of recrystallization from cristobalite and by Lehtinen (1976) to be due to thermal stress. Plagioclase fragments show a curious spotty appearance which Robertson considers to be the result of later thermal effects on the shocked feldspar lattice. There are also devitrification(?) patches of colourless radiating chlorite and albite. Subhedral grains of zircon are present.

Table 34. Modal compositions of diabase (Unit 16) from intrusions in the Rottenstone Domain

Dept. No. 7508-	Rock Name	Pyroxene (Augite)	Amphibole	Biotite	Opaque Ore	Plagioclase	Quartz/ Microcline Granophyric Intergrowth	Accessory Minerals
0010	Subophitic augite-actinolite diabase	35*	5(Act?)	-	5	55	Trace	-
0044	Chilled augite-hornblende diabase	2*	Trace (Hb)	-	Abundant	3* (microliths)	-	Cbt (in vein)
0079	Subophitic augite diabase	40	-	-	5	55	-	Ap
0089	Subophitic augite-hornblende diabase	45**	2(Hb)	-	3	50	Trace	Ap
0221	Subophitic augite-biotite-hornblende diabase	35	← 5(+Ep) →		5	50(An_{60})	5	Ap

See Appendix B for explanation of symbols used.

In the second section (0074), composed of suevite, highly angular fragments of strained quartz and microcline and very altered plagioclase are supported in a recrystallized extremely fine grained groundmass consisting largely of granular epidote and greenish albitic plagioclase or chlorite. A crude flow foliation is locally preserved in the groundmass and is enhanced by a distinct preferred orientation of crystal and lithic fragments. Biotite is also present (e.g. as a large bent crystal rimmed by chlorite). An inclusion of weakly foliated granodiorite is composed of 5 percent moderate to dark brown biotite, 55 percent completely saussuritized plagioclase, 30 percent highly strained elongated quartz and 10 percent fresh microcline.

Paull River Shear Zone

Biotite Tonalite/Trondhjemite (Subunit 11a)

Only one main lithologic unit has been distinguished on the map: intensely sheared biotite tonalite/ trondhjemite (Subunit 11a). This same rock type outcrops in both the Rottenstone Domain to the northwest and the La Ronge Domain to the southeast. Migmatite bands are present but are too narrow and discontinuous to distinguish separately. The unit is comparatively resistant to erosion and forms a ridge of high ground which separates Hickson Lake from Fields Lake. Aeromagnetic relief is low, with intensities in the range 3400 to 3500 gammas.

The unit varies in width from 200 to 1750 m. The shear splits into two branches between Church Island and the northeastern end of Fields Lake. The more northerly branch is subsidiary and appears to die out along strike about 3 km northeast of Fields Lake. The main southerly branch continues northeastwards into the Hickson Lake area (Gracie, 1965) where it has been traced as far as the southeast shore of Oneman Lake. The probable continuation of the shear zone has been mapped by Lewry (1975) northeast of Macoun Lake. To the southwest, it has been described by Ray (1974, 1980) in the Foster Lake (south) and La Ronge (northwest) areas, by Morris (1960) in the Black Bear Island Lake area and probably by Forsythe (1972) in the Clam Lake area.

In outcrop the rock is an augeniferous gneiss with an intense foliation wrapped around remnant feldspar porphyroclasts. The gneiss is predominantly biotite bearing, but muscovite is locally a prominent constituent. Flattened lenticles of quartz are characteristic. Rare thin fine-grained mylonite zones 0.5 to 2 cm wide are present in this otherwise whitish medium-grained granitoid rock. There are numerous xenoliths and schlieren of biotite schists and gneisses and less abundantly of amphibole-bearing schists. The xenoliths locally contain garnets elongated along the foliation.

Three rock samples from this unit have been examined in thin section (Table 35). One of these, consisting of sheared muscovite-biotite monzogranite (0103), was found to have a high microcline content. *Muscovite* occurs as well-oriented flakes which vary considerably in size from 0.2 to 2 mm; all are deformed and show undulose extinction. *Biotite* is present as small (less than 1 mm across) well-oriented flakes interleaved with muscovite. Some strain effects have been noted. *Quartz* is slightly fractured, extremely strained and shows some elongation parallel to the main foliation. *Plagioclase* is of oligoclase composition and is slightly sericitized. *Microcline* forms both interstitial grains and large phenocrysts. The only identified *accessory mineral* is zircon. There is some marginal recrystallization of felsic mineral phases; otherwise, intergranular boundaries are of highly irregular shape.

Two sections (both 0104) were prepared from xenolithic material within sheared tonalitic/ trondhjemitic gneiss. One of these, classified as garnetiferous biotite schist, contains pale straw yellow to moderate brown *biotite*; *quartz* as small (less than 1 mm across) strained irregularly shaped grains; and *plagioclase*, slightly sericitized and containing many rounded quartz inclusions. The *accessory minerals* include apatite, zircon and large subidioblastic garnets which, although containing many inclusions (predominantly quartz and plagioclase), show no internal schistosity.

Table 35. Modal compositions of intrusive rock (Unit 11) and migmatitic metasedimentary rock (Unit 10) in the Paull River Shear Zone

Dept. No. 7508-	Rock Name	Biotite	Muscovite	Hornblende	Garnet	Quartz	Plagioclase	Microcline	Accessory Minerals
0103	Sheared muscovite-biotite leucomonzogranite	5‖	10‖	-	-	30‖	28(oligoclase)*	27	Zr
0104	Interbanded garnet-biotite gneiss and hornblende-garnet gneiss	8	-	20	17 e*	25	30**	-	Zr, Ap, Op, Chl
0104	Pelitic biotite-garnet schist	30‖	-	-	Trace e	35	35*	-	Zr, Ap, Op

See Appendix B for explanation of symbols used.

Xenoblastic textures predominate but granoblastic textures are locally evident.

The other thin section, consisting of garnetiferous biotite gneiss interbanded with garnetiferous amphibole gneiss, contains *hornblende*, pleochroic in moderate shades of brown and olive green, *biotite*, and *garnet* as xenoblastic crystals full of inclusions of quartz, opaque ore, biotite and sericitized plagioclase. A weakly defined internal schistosity in the garnets is parallel to the principal schistosity in the rock. *Quartz* as small strained grains forms only 15 percent of amphibole-rich bands but about 25 percent of the rock as a whole. *Plagioclase* is almost completely saussuritized. The main *accessory minerals* zircon, apatite and locally developed chlorite.

La Ronge Domain

Rocks of the La Ronge Domain underlie about 175 km^2 in the southeast corner of the area. Five major lithologic units have been recognized, but almost half the area is occupied by granitoid rocks of the Hickson Lake Batholith (Units 19 and 20).

Unit 18 and Subunit 18a are pelitic schists in part intruded by granitoid material. The relationship of the predominantly foliated tonalite/trondhjemite (Unit 11) is unclear; it may represent the original rock from which the Hickson Lake Batholith was remobilized. Rocks assigned to the migmatitic gneisses (Unit 10), although not in direct contact with the pelitic schist (Unit 18), are considered to be intruded equivalents of this unit.

Aeromagnetic relief in the La Ronge Domain is smooth and mainly in the range 3400 to 3500 gammas, except for the pelitic schists which range from slightly less than 3400 gammas to more than 3550 gammas. Aeromagnetic trends in this unit parallel the schistosity.

Migmatitic Gneisses (Unit 10)

Migmatitic gneisses crop out over an area of about 20 km^2 in the northwestern part of the La Ronge Domain. They are in juxtaposition with the Paull River Shear Zone to the northeast of Church Island. They are well exposed along the northwestern shore of Hickson Lake, generally forming banded migmatite in which the dominant paleosome is pelitic or semipelitic schist or gneiss, locally garnetiferous. Psammitic and amphibolitic paleosome is somewhat less abundant. The neosome is generally weakly foliated whitish biotite-bearing tonalite to granodiorite.

Seven samples of paleosome were examined in thin section (Tables 36 and 37). Of these, two are pelitic schists (0106, 0112), two are semipelitic schists (0107, 0110) and three are amphibole-bearing schists. Table 38 summarizes the modal compositions of the three types of schist. No thin sections of the neosome were examined.

Biotite in the pelitic and semipelitic schists is generally well oriented, dichroic in shades of pale straw yellow to dark brown and ranges in size from 0.2 to 2 mm. Some flakes are sharply transverse to the main orientation. Where the rock displays folding (0106) the mineral is mimetically recrystallized

Table 36. Modal compositions of psammitic and pelitic schists from migmatitic horizons (Unit 10) in the La Ronge Domain

Dept. No. 7508-	Rock Name	Biotite	Muscovite	Quartz	Plagioclase	Microcline	Accessory Minerals
0106	Folded pelitic biotite schist	40‖ x	-	20‖	40*	-	Zr, Ap
0107	Semipelitic biotite schist	10‖ *	-	35‖	55*	-	Zr, Ap, Op, Chl
0110	Semipelitic biotite schist	10‖ x	-	35‖	55	-	Zr, Ap
0112	Pelitic muscovite-biotite schist	10‖	15‖	←	75	→	Zr, Ap, Op‖

See Appendix B for explanation of symbols used.

Table 37. Modal compositions of amphibole ± biotite ± garnet schists from migmatitic horizons (Unit 10) in the La Ronge Domain

Dept. No. 7508-	Rock Name	Biotite	Amphibole	Garnet	Quartz	Plagio-clase	Micro-cline	Accessory Minerals
0108	Biotite-actinolite schist	17‖	8(Act)	-	15‖	60*	-	Zr, Ap, Op
0109	Folded hornblende schist	Trace	45(Hb)‖	-	Present in veins	55**	?	Ap, Op, Sph
0111	Actinolite-biotite-garnet schist	17‖ x	18(Act)‖ x	Trace ⊕	15	50*	-	Zr, Op

See Appendix B for explanation of symbols used.

Table 38. Summary of modal compositions of paleosome of migmatitic gneisses (Unit 10), La Ronge Domain

Mineral	*Pelitic Schists*	*Semipelitic Schists*	*Amphibole-bearing Schists*
Biotite	10-40	~10	trace-17
Muscovite	0-15	-	-
Amphibole	-	-	8-45
Quartz	~20+	~35	trace-15
Plagioclase	~40+	~55	50-60

around the hinges of microfolds. *Muscovite* (1 to 2 mm) forms well-oriented flakes. *Quartz* grains are generally less than 1 mm across, irregularly shaped, highly strained and elongate parallel to the main schistosity. *Plagioclase* (oligoclase) forms small grains many of which are untwinned. Zoning occurs in one specimen (0110); sericitization is absent (0110) to slight. *Microcline* has been identified in only one section (0112), where it is a phase in a monzogranitic vein (50 percent quartz, 30 percent highly saussuritized plagioclase and 20 percent microcline).

Actinolite is present in two of the three amphibole-bearing sections (0108, 0111) and *hornblende* occurs in the third (0109). Actinolite poikiloblastically encloses quartz and shows weak preferred orientation. Hornblende shows good preferred orientation and is mimetically recrystallized around a fold hinge. *Biotite* is well (0108) to moderately well (0111) oriented. There are many grains with transverse orientation in 0111. Dichroism varies from pale straw yellow to moderate brown. *Quartz* is slightly (0111) to highly (0108) strained, with 0108 showing elongation parallel to the main schistosity. Grains are usually less than 1 mm across. *Plagioclase* (oligoclase/andesine) is weakly to almost completely sericitized and shows weak zoning (0111). *Garnet* is present in one slide (0111), where it is full of quartz inclusions but lacks an internal schistosity.

Zircon and apatite occur as *accesory minerals* in all samples except one of the amphibole-bearing schists. Opaque ore, chlorite and sphene are also present.

Intergranular boundaries are irregular, but local subgranoblastic textures are developed (0106, 0107, 0110, 0111) where annealing appears to have occurred.

Biotite Tonalite/Trondhjemite (Unit 11)

Rocks of this unit crop out over an area of about 17 km^2 immediately southeast of the Paull River Shear Zone southwest of Church Island. These rocks are considered to be equivalent to the biotite tonalite/trondhjemite (Unit 11) northwest of the Paull River Shear Zone, a correlation also suggested by Ray (1980).

The rock is medium to coarse grained, white to pale pink, equigranular and well foliated.. Biotite is ubiquitous and muscovite is also present in places. The only thin section examined from this unit was a xenolith of fine-grained psammitic biotite schist (Table 39). It was found to contain *biotite* as small well-oriented flakes dichroic from pale straw yellow to moderate brown, *quartz* as small strained grains slightly elongate parallel to the main schistosity and *plagioclase* which is slightly sericitized. The schist has a granoblastic texture; triple-point junctions are common.

Biotite ± Muscovite ± Graphite Schists (Unit 18)

These pelitic and semipelitic schists, which occupy about 35 km^2, are the most distinctive rocks of the La Ronge Domain in this area. A section of the schists adjacent to the Hickson Lake Batholith has been intensely injected with granitoid material (Subunit 18a). Deformation throughout has been intense and the schists are tightly folded about steeply plunging axes.

Inland from the large lakes the pelites are well exposed and form level ground. The rocks are remarkably homogeneous with only rare horizons of amphibolite and hornblende-biotite gneiss.

In outcrop, the rock is generally fine grained mica rich (containing both muscovite and biotite) and moderate grey in colour. Migmatitic segregations are lacking but veins of muscovite-bearing granitoid material varying in width from a few centimetres to a few metres are common. These veins, which cut across the schistosity, are locally foliated. This foliation is an axial planar schistosity (Figure 15). The only metamorphic mineral noted was sillimanite, close to the contact with the Hickson Lake Batholith. Eight samples of pelitic (and semipelitic) schist were examined in thin section (Table 39).

Biotite forms small (0.1 to 1 mm long, mostly 0.3 to 0.5 mm) well-oriented flakes which are dichroic from almost colourless or pale straw yellow to moderate brown or reddish brown. Where microfolds are developed, biotite is parallel to (0105) or cuts across (0105, 0274) axial planes. In places the mineral contains many pleochroic haloes (0097). *Muscovite* flakes are generally more variable in size, ranging from less than 1 mm (0273) to 3 mm (0268) in length; although less oriented than biotite, they show similar relationships to microfolds. *Graphite* as small intergranular flakes reaches 0.1 mm in length.

Table 39. Modal compositions of pelitic and semipelitic schists and gneisses from the metasedimentary rocks (Unit 18) of the La Ronge Domain

Dept. No. 7508-	Rock Name	Biotite	Muscovite	Graphite	Silli-manite	Quartz	Plagioclase	Micro-cline	Accessory Minerals
0094	Pelitic biotite schist	25	-	-	-	40	20	15	Zr, Ap
0096	Pelitic biotite-muscovite schist	18	7	-	-	50	20	5	Zr, Ap
0097	Semipelitic biotite-sillimanite gneiss	22 *	-	-	3	50	25*	-	Zr, Ap
0105	Pelitic muscovite-biotite schist	10 x	40 xf	-	-	45	-	-	Op(5)
0268	Pelitic muscovite-biotite schist	15 x	25 x	-	-	25	20(An_{28})	15	Zr, Ap, Op
0273	Pelitic muscovite-biotite schist	18 x	22 x	-	-	30	30(An_{30})*	-	Zr, Ap, Op
0274	Folded pyritiferous pelitic graphite-biotite schist	12	Trace	13	-	38	30*	-	Zr, Ap, Op(7), Ru(?)
0275	Pyritiferous pelitic graphite-biotite schist	10 x*	-	13	-	31	34(An_{30})*	5	Zr, Ap, Op(7), Ru(?)

See Appendix B for explanation of symbols used.

Underlined sample has been geochemically analyzed.

Quartz forms irregularly shaped grains which are usually less than 1 mm across, although rare grains reach diameters of 2 mm. The mineral generally shows undulose extinction and some flattening parallel to the main mica schistosity. Variation in concentration may be either metamorphic (0097) or a primary depositional feature (0275). *Plagioclase* (An_{28-30}) generally untwinned is fresh or slightly sericitized. Weak zoning occurs in places (0097, 0273). Grain size is less than 1 mm with most crystals about 0.5 mm across. *Microcline* is fresh and forms either cross-hatched interstitial grains 0.1 to 0.2 mm across or exsolved and/or replacement patches in plagioclase (0268).

Of the transparent *accessory minerals*, idioblastic apatite is the most abundant and is 0.1 to 0.2 mm across. Small rounded zircons are common, while rutile is a rare accessory. Sillimanite is present as fibrolite (0097); crenulated in places, it shows close spatial relationship with biotite. Several sections contain sulphide mineralization (0105, 0274, 0275). A polished section of 0274 shows xenoblastic to idioblastic grains of pyrite up to 0.5 mm across surrounding a core of an unknown mineral (lost during slide preparation). Where this core has been largely replaced by opaque sulphide, pyrite grains show centres full of dusty inclusions. Trace amounts of chalcopyrite form marginal to the pyrite and as discrete grains. Small (0.1 mm) subidioblastic magnetite crystals contain concentrically arranged dusty inclusions.

Granoblastic and subgranoblastic textures are widespread in these rocks.

Sample 0274 has been geochemically analyzed for major oxides and assayed for Fe, Cu Ni, Zn, Ag and Au. Results are given in Table 55 (Appendix D).

Four samples from amphibole-bearing horizons within pelitic metasediments were examined in thin section (Table 40).

Amphibole appears to be actinolite in sections 0269 and 0270, and hornblende in sections 0271 and 0276; the hornblende is locally altered to tremolite and chlorite (0276). It forms xenoblastic crystals, many of which poikiloblastically enclose plagioclase, sphene, quartz and/or microcline. *Biotite* flakes vary in length from 1 to 2 mm; the larger grains are ragged and enclose quartz. The smaller grains are locally

Table 40. Modal compositions of amphibolites from the metasedimentary rocks (Unit 18) of the La Ronge Domain

Dept. No. 7508-	Rock Name	Biotite	Amphibole	Quartz	Plagioclase	Micro-cline	Accessory Minerals
0269	Pyritiferous amphibolite	2	35(Act)	5	40(An_{55})*	3	Ap, Op(12), Sph(3)
0270	Pyritiferous amphibolite	-	45(Act)	1	40(An_{50})**	1	Ap, Op(8), Sph(5), Cbt
0271	Biotite amphibolite	17x	48(Hb?)	-	30**	-	Zr, Ap, Op(2), Sph(3), Ms
0276	Hornblende-biotite gneiss	3	20(Hb) *	30	34(An_{44})**	12	Zr, Ap, Op, Sph(1), Ep, Chl

See Appendix B for explanation of symbols used.

Underlined sample has been geochemically analyzed.

altered to chlorite. *Sphene* tends to form complete or partial rims around grains of opaque ore (0269, 0271).

Quartz occurs in significant amounts only in section 0276, where it is strained and shows sutured interquartz boundaries and pronounced elongation parallel to the main schistosity. *Plagioclase* (An_{44-55}) exhibits slight to extreme alteration to saussurite and in some sections is strongly zoned (0270, 0271). In section 0270 plagioclase appears to be concentrated into granoblastic equidimensional patches about 1.5 mm in diameter. *Microcline* is present in small amounts.

Opaque ore (pyrrhotite with lesser chalcopyrite), the most abundant of the *accessory minerals*, is evenly disseminated throughout the rock. Separate grains of iron oxide minerals are also present. Other accessory minerals include apatite, zircon, epidote, chlorite, muscovite and carbonate.

Granoblastic textures in these amphibole-bearing rocks are well developed except in section 0276, where intergranular boundaries are extremely irregular and are sutured between quartz grains.

One sample (0269) has been geochemically analyzed for major oxides and assayed for Fe, Cu, Ni, Zn, Ag and Au. The results are in Table 55 (Appendix D).

A single sample (0095) of granitoid material injected into these predominantly pelitic metasediments has been examined in thin section (Table 41). It was found to be garnetiferous muscovite leucogranodiorite. Crystal boundaries are irregular, with extensive marginal recrystallization resulting in partial development of granoblastic textures.

Amphibole-Biotite Quartz Diorite and Quartz Monzodiorite (Unit 19)

Rocks of this unit crop out over an area of about 5 km^2 in the extreme southeast corner of the area. Exposure is good although the terrain is of low relief. The rock is medium to coarse grained and very uniform. It is weakly foliated close to the margins of the intrusive body where biotite exceeds amphibole in abundance. Away from the margins the rock becomes increasingly massive and amphibole is more abundant than biotite.

Plagioclase tends to form as phenocrysts up to 1 cm in length. The unit is cross-cut by narrow veins of leucocratic fine-grained biotite granite. Although no actual contact with the pelitic metasediments was observed, it was located to within 15 m. No thermal metamorphism of the pelites was apparent (section 0273). Three samples of this rock type were examined in thin section (Table 42). All were collected from within several kilometres outside of the area.

Biotite is well (0113) to randomly (0114) oriented and dichroic from pale straw yellow to moderate red-brown, exhibiting many pleochroic haloes around apatite and sphene. Grain size ranges from 0.5 to 1.5 mm. A few grains show alteration to chlorite along cleavage planes. *Amphibole* is actinolite in sections close to the margin of the mass (0113, 0272) and hornblende in a more centrally situated sample (0114). Crystals are irregular in shape, most have diameters of 1 to 2 mm and orientation is good to random. There is marginal alteration to biotite in section 0113.

Quartz is present as grains 0.5 to 1.5 mm in length which are slightly elongated parallel to the main foliation (0272), and as smaller fractured highly

Table 41. Modal composition of granitic vein invading predominantly pelitic metasediments (Unit 18) of the La Ronge Domain

Dept. No. 7508-	Rock Name	Muscovite	Garnet	Quartz	Plagio-clase	Micro-cline	Accessory Minerals
0095	Weakly foliated muscovite-garnet leucogranodiorite	25≈	1	44	25	5	Zr, Op

See Appendix B for explanation of symbol used.

Table 42. Modal compositions of rocks from the quartz diorite/quartz monzodiorite intrusion (Unit 19) in the La Ronge Domain

Dept. No. 7508-	Rock Name	Biotite	Amphibole	Quartz	Plagioclase	Micro-cline	Accessory Minerals
0113	Foliated biotite-actinolite quartz diorite	10‖	10(Act)‖*	5	75(oligoclase/andesine)*	-	Zr, Ap, Op, Sph
0114	Massive hornblende-biotite quartz diorite	12x	20(Hb)x	8	57(oligoclase/andesine)*	3	Zr, Ap, Op, Sph, Ep
0272	Foliated actinolite-biotite quartz monzodiorite	6*	10(Act)	18≈	54(An_{30})‖*	12	Zr, Ap, Op, Sph, Chl

See Appendix B for explanation of symbols used.

strained grains (0114, 0272). *Plagioclase* (oligoclase/andesine) forms phenocrysts exceeding 6 mm in length with good subparallel orientation (0272) or no preferred orientation (0113, 0114). Twin lamellae are much bent and the grains highly strained. Slight sericitization is common and a weak zoning occurs in section 0114. There are inclusions of biotite and patches of microcline. *Microcline* where present forms discrete grains up to 1 mm in length and smaller interstitial grains.

The main *accessory minerals* are zircon, multizoned in section 0272 but elsewhere as extremely small crystals; opaque ore as grains (0113) and granular accumulations (0272); apatite; and sphene. Epidote and chlorite are locally present as alteration products.

Myrmekite is present in microcline-bearing rocks. Intercrystal boundaries are irregularly shaped, except in 0113 where granoblastic textures are locally developed between quartz and feldspar. There is some marginal recrystllization to smaller grain size in section 0272.

Biotite ± Muscovite Granodiorite/Monzogranite of the Hickson Lake Batholith (Unit 20)

Well-exposed massive equigranular pale pink granitoid rocks of the Hickson Lake Batholith occupy about 80 km^2 of the La Ronge Domain in this area. Contact with the migmatite (Unit 10) and tonalite/trondhjemite (Unit 11) complex to the northwest is gradational; in places close to the contact there are low angle shear zones in the batholith. Both these rocks to the northwest and the metasedimentary rocks to the southeast (Subunit 18a) are cut by veins and dykes of massive granitoid rock which are probably genetically related to the batholith. Emplacement of the majority of these dykes and veins preceded a period of tight folding: they commonly display an axial planar muscovite schistosity. The main intrusive mass contains few xenoliths, and is injected by late biotite- and/or muscovite-bearing pegmatitic phases which form small irregularly shaped bodies up to 5 m across and 30 m or more in length. Although not sampled, beryl was reported in these pegmatites.

Thirteen samples from the batholith have been examined in thin section (Table 43).

Biotite is weakly (0115, 0116) to randomly oriented and generally fresh, although partially chloritized in sections 0289 and 0291. Pleochroic haloes are rare to abundant (0289, 0292). Dichroic colours vary from pale straw yellow to dark brown. *Muscovite* is intergrown with biotite.

Quartz generally forms slightly fractured, highly strained grains 2 to 5 mm across; slight elongation occurs in section 0116. *Plagioclase* (oligoclase) shows slight to pronounced alteration to sericite or more rarely saussurite; the grain cores are most affected (0116, 0289, 0290, 0291, 0295). Crystal size is generally in the range 2 to 4 mm. Weak zoning is

Table 43. Modal compositions of predominantly massive biotite ± muscovite granodioritic rocks (Unit 20) which form the Hickson Lake Batholith in the La Ronge Domain

Dept. No. 7508-	Rock Name	Biotite	Muscovite	Quartz	Plagioclase	Microcline	Accessory Minerals
0115	Massive pegmatitic leucomonzogranite	Trace	Trace	33	27(oligoclase)*	40(s)	-
0116	Weakly foliated biotite-muscovite granodiorite	9≈	1x	25≈	50(oligoclase)*	15	Zr, Ap
0117	Weakly foliated biotite granodiorite	5≈	Trace	25	55(oligoclase)*	15	Zr
0118	Biotite muscovite leuco-quartz monzonite	8x	Trace	12	45**	35	-
0120	Massive pegmatitic muscovite leucomonzogranite	-	4	60	20**	15	Ap(1%)
0121	Massive biotite leucomonzogranite	3x	Trace	35	27(oligoclase)*	35(s)	-
0289	Massive biotite granodiorite	9x*	1x	35	40(oligoclase)*	15	Zr, Ap
0290	Massive biotite monzogranite	8x*	Trace x	20	38(oligoclase)*	34(p)	Zr, Ap, Op
0291	Massive biotite granodiorite	8x*	Trace x	35	45(oligoclase)*	12	Zr, Ap, Op
0292	Massive biotite granodiorite	10x	Trace x	35	48(oligoclase)*	7	Zr, Ap, Op
0293	Massive biotite tonalite	10x	Trace x	25	65(oligoclase)*	Trace	Zr, Ap, Op
0294	Massive biotite-muscovite leucomonzogranite	3x	2x	30	25(oligoclase)*	40(s)	Zr
0295	Massive biotite-muscovite leucosyenogranite	4x	1x	20	20(oligoclase)*	55(s)	Zr, Ap, Op

See Appendix B for explanation of symbols used.

Underlined samples have been geochemically analyzed.

shown in sections 0117, 0292 and 0293. Slightly bent twin lamellae are also a rare feature (0117, 0121, 0294). Inclusions of quartz, biotite and microcline occur in some grains (0289, 0290, 0293, 0294). *Microcline* mainly forms small interstitial grains less than 1 mm across, although phenocrysts exceeding 1 cm in length are present (0115, 0121, 0290, 0295). They contain inclusions of quartz, biotite and sericitized albite-rimmed plagioclase, and rare exsolved patches (0290) or lamellae (0115, 0121, 0294, 0295) of plagioclase.

The common *accessory minerals* are zircon, apatite and opaque ore.

Textures are everywhere xenomorphic. Traces of myrmekitic intergrowth at plagioclase/microcline contacts are common.

Geochemistry

Whole rock geochemical analyses were carried out on suites of rocks collected from three distinctive granitoid masses, one situated in each of the three lithostructural domains in the area, and on four supracrustal rock samples, three of which were highly pyritiferous. At each sample site (shown on Map 193A, back pocket) 2 to 5 kg of fresh chipped material were obtained. Great care was taken to ensure that there was no contamination by xenolithic or vein material and that all chip surfaces were unaffected by weathering. The samples were submitted to the geochemical laboratory, University of Regina for crushing and analysis of major elements (as oxides) and certain trace elements. Laboratory procedures are described in Appendix C.

Geochemistry of Granitoid Rocks

Anderson Lake Inlier, Wollaston Domain

Tables 44 and 45 (Appendix D) show major oxide and trace element concentrations of six samples selected from the northeastern end of this granitoid body. Table 46 (Appendix D) shows CIPW norms for each sample, calculated from their major oxide analyses. These data were plotted onto various ternary diagrams. On the FMA diagram (Figure 4), the sample points cluster in a well-defined field on the MgO-depleted border of which lies the point representing the Le Maitre "average granite". A similar cluster is formed by samples from this granitoid on the KCN diagram (Figure 5), where they are richer in alkalis, particularly K_2O, than the Le Maitre average granite. The sample points on the normative Qz-Or-Ab diagram (Figure 6A) lie close to the eutectic compositions in the Qz-Ab-Or-H_2O system at $pH_2O \simeq 7$-10 kb, Ab/An = 2.9. On the normative An-Or-Ab diagram (Figure 7A) the points lie close to the cotectic line on the orthoclase side. Comparing the abundances of the seven trace elements analyzed (Table 45, Appendix D) with their average abundance in granite (Taylor, 1966), Nb, Rb and Y are normal, V and U are slightly depleted, Sr is strongly depleted and Zr is strongly enriched.

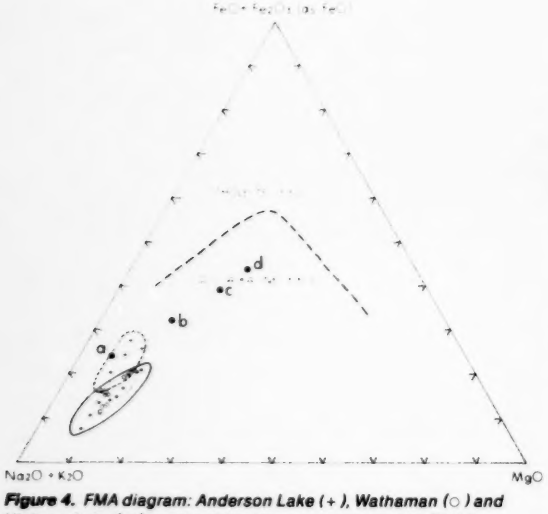
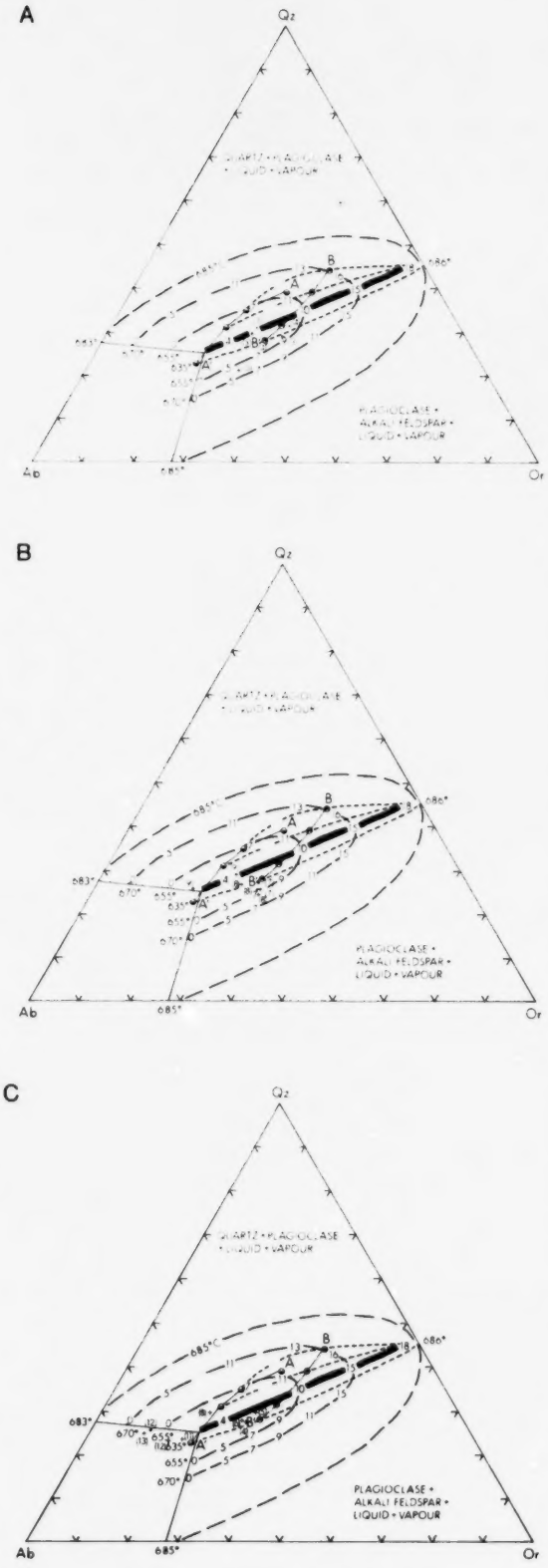


Figure 4. *FMA diagram: Anderson Lake (+), Wathaman (○) and Hickson Lake (●) granitoid bodies. a, average granite (2458 analyses); b, average granodiorite (855 analyses); c, average tonalite (97 analyses); d, average diorite (872 analyses); all from Le Maitre (1976). Broken line separates fields of tholeiitic and calc-alkaline trends (Irvine and Baragar, 1971)*

Figure 5. *KCN diagram: Anderson Lake (+), Wathaman (○) and Hickson Lake (●) granitoid masses, and supracrustal rocks (⊕). a to d, as defined in Figure 4. AA', variation trend for rocks of the calc-alkaline southern California batholith (from Turner and Verhoogan, 1960, after Nockolds and Allen, 1953, 1954)*

Wathaman Batholith, Rottenstone Domain

Analytical data have been tabulated (Tables 47 to 49, Appendix D) and plotted onto ternary diagrams. The field defined by these samples on the FMA diagram (Figure 4) slightly overlaps that of the Anderson Lake mass but is higher in total alkalis. The samples plot on the KCN diagram (Figure 5) in an ovoid field which is separate from and richer in Na_2O and CaO than that of the Anderson Lake Inlier; Le Maitre's average granite plots close to the potassic end of this field. Points plotted on the normative Qz-Or-Ab diagram (Figure 6B) are somewhat more scattered than those of the Anderson Lake Inlier. Nevertheless they show a marked concentration close to B', the high pH_2O (10 kb) low temperature (645°C) end of the line showing eutectic compositions in the Qz-Ab-Or-H_2O system at various pH_2O where Ab/An = 2.9. On the normative An-Or-Ab diagram (Figure 7B) most points lie close to the cotectic line in the plagioclase field. They fall on the albitic side of the trend expected from differentiation of basic magma. Trace element abundances (Table 48, Appendix D) are, relative to



Taylor's averages for granite, normal for V, normal to enriched for Sr, normal to depleted for Zr, depleted for Rb and Nb, and strongly depleted for Y and U.

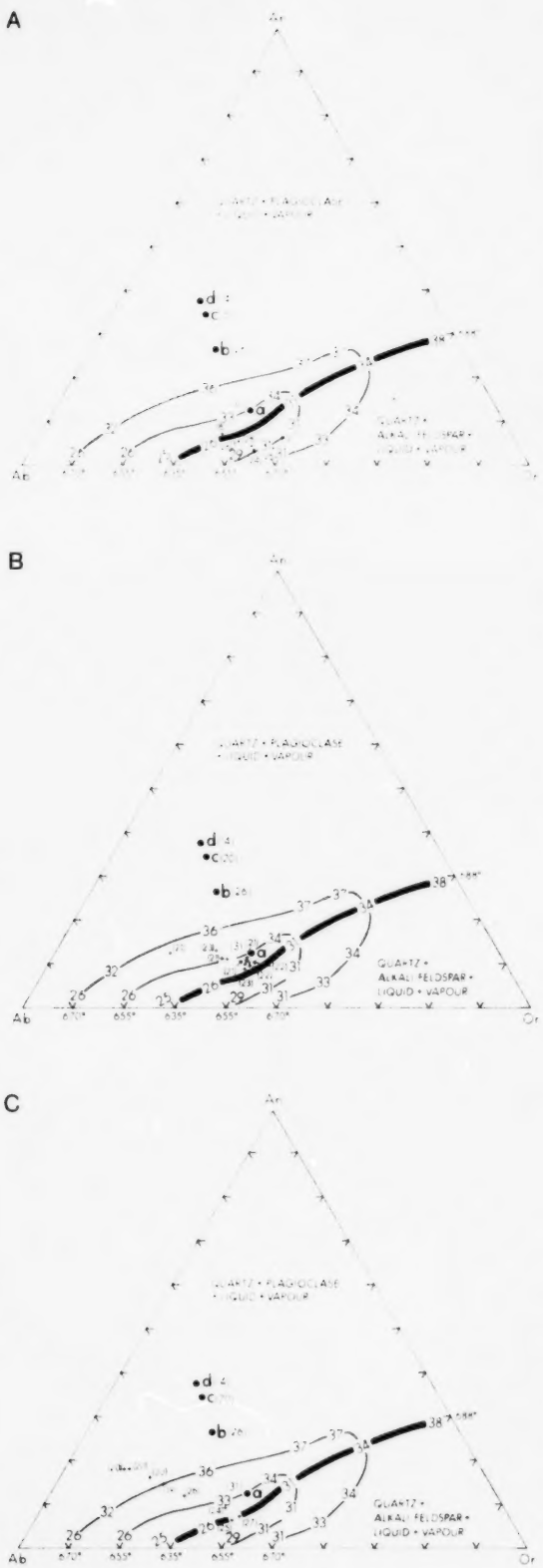
Hickson Lake Batholith, La Ronge Domain

Analytical data for the Hickson Lake Batholith have been tabulated (Tables 50 to 52, Appendix D) and plotted onto ternary diagrams. On the FMA diagram (Figure 4) the points define a field larger than and superimposed upon that for the Wathaman Batholith. A larger considerably elongated field is defined on the KCN diagram (Figure 5); a linear trend is apparent, lying on the sodic side of the variation trend developed by rocks of the calc-alkaline southern California batholith (Turner and Verhoogan, 1960). The normative Qz-Or-Ab diagram (Figure 6C) shows that points are once again widely distributed and generally lie close to the projections of two of the three cotectic lines (one separating the quartz and plagioclase fields, the other separating the quartz and orthoclase fields). The normative An-Or-Ab diagram (Figure 7C) shows sample points falling along a pronounced linear trend in the plagioclase field; the most Or-rich specimens fall on the cotectic line separating the plagioclase and orthoclase fields. Trace element abundances (Table 51, Appendix D) are, in comparison with Taylor's average granite, about normal for V, normal to enriched for Sr, normal to depleted for Rb, depleted for Nb and strongly depleted for U and Y.

Geochemistry of Supracrustal Rocks

The four supracrustal rocks analyzed (Tables 53 and 54, Appendix D) were: pyritiferous diopside-actinolite-biotite gneiss (0062), Rottenstone Domain; pyritiferous amphibolite (0269), La Ronge Domain; folded pyritiferous pelitic graphite-biotite schist (0274), La Ronge Domain; and calcareous psammite (0283) from the contact between the probable Archean granitoid and the Aphebian metasediments in the Wollaston Domain. The iron-rich nature of the sulphide-bearing rocks is reflected by their high FeO or Fe_2O_3 values. Samples 0062 and 0269 have high MgO and CaO vales, mostly contained within amphibole and pyroxene. Low major oxide values are recorded for Al_2O_3 in sample 0283, Na_2O in all

Figure 6. *Normative Qz-Or-Ab diagrams: A, Anderson Lake Inlier; B, Wathaman Batholith; C, Hickson Lake Batholith. a to d, as defined in Figure 4. Projections of the cotectic lines (heavy) and of isotherms (light) on two of the three cotectic surfaces of the system Qz-Ab-Or-An-H_2O at 7 kbars water pressure are from Winkler (1976). Numbers on the isotherms indicate the amount (in weight percent) of anorthite in the melt. Number in parentheses beside each analysis shows the percentage of normative quartz present. AA', eutectic compositions at various pH_2O (0.5-10.0 kbars), Ab/An = ∞; BB', eutectic compositions at various pH_2O (2.0-10.0 kbars), Ab/An = 2.9*



samples except 0274 and K_2O in 0062 and 0269. Loss-on-ignition is high (6.58 percent) in the graphitic pelite. Trace element abundances (Table 54, Appendix D) show no anomalous values, although V is generally high (except 0283); the highest U content (3.1 ppm) in the area was obtained from the graphitic pelite.

Summary

Geochemical analyses, especially of rock suites collected from granitoid masses in each of the lithostructural domains that cross the map area, have yielded much useful information. Each granitoid sampled appears to have a characteristic major oxide and trace element constitution, but further work is needed to confirm the analytical similarities and differences outlined above. Uranium is of special interest in view of its economic importance in northern Saskatchewan. On a regional basis this element has low concentrations in the granitoids, particularly the Wathaman Batholith. Its depletion in the map area (and elsewhere in the region?) might be due to its concentration into ore bodies situated to the northwest.

Figure 7. *Normative An-Or-Ab diagrams: A, Anderson Lake Inlier; B, Wathaman Batholith; C, Hickson Lake Batholith. a to d, as defined in Figure 4. Projections of the cotectic lines (heavy) and of isotherms (light) on the cotectic surfaces of the system Qz-Ab-Or-An-H_2O at 7 kbars water pressure are from Winkler (1976). Numbers on the isotherms indicate the amount (in weight percent) of anorthite in the melt. Number in parentheses beside each analysis shows the percentage of normative quartz present*

Geochronology

The suites of rock collected for geochemical analysis from the Anderson Lake Inlier and the Wathaman and Hickson Lake Batholiths were submitted to the Department of Geology at Carleton University for age dating using the Rb/Sr isochron method.

The Anderson Lake Inlier failed to yield an isochron. The isotopic data are tabulated (Table 55), and are plotted in Figure 8 on which an arbitrarily chosen isochron of 2500 Ma is shown for reference purposes only (Bell, 1979). Bell (1979) states that, although the scatter of data points for this and similar Wollaston Domain granitoids (Johnson River, Pederson Lake) is too great to ensure reliable interpretation, the results are consistent with their 2600 ± 100 Ma age of formation. The scatter can be most readily explained by 1) their open-system behaviour subsequent to emplacement and/or 2) their non-uniform Sr-isotopic composition when still magmatic.

Table 55. Rb/Sr analytical data, Anderson Lake Inlier, Wollaston Domain

Dept. No. 7508-	Rb (ppm)	Sr (ppm)	Rb/Sr (weight)	$^{87}Sr/^{86}Sr$[1] (atomic)	$^{87}Rb/^{86}Sr$ (atomic)
0284	171	76	2.25	0.9339	6.65
0285	158	128	1.23	0.8262	3.61
0286	176	85	2.07	0.9399	6.12
0288	153	64	2.39	0.9768	7.10
0318	158	163	0.97	0.8104	2.83

[1]normalized to a $^{86}Sr/^{88}Sr$ ratio of 0.1194

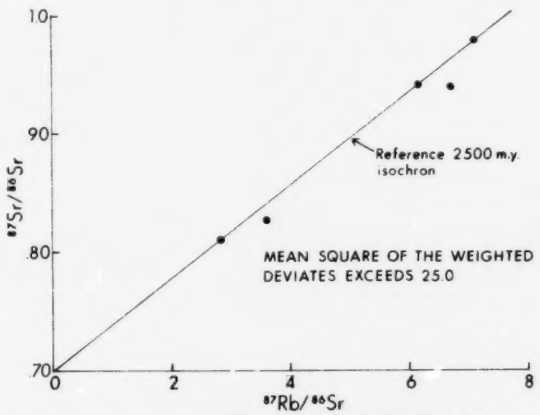


Figure 8. *Isotopic data, Anderson Lake Inlier, Wollaston Domain; the 2500 Ma isochron is shown for reference purposes only (Bell, 1979)*

The Wathaman Batholith samples despite their widespread geographic distribution showed highly uniform Rb/Sr ratios and were therefore considered to be unsuitable for dating by the Rb/Sr isochron method. However, rock suites subsequently collected from this batholith were dated both by U/Pb zircon methods (1856 ± 12 Ma, Ray and Wanless, 1980) and by obtaining a whole rock Rb/Sr isochron (1890 ± 45 Ma, initial $^{87}Sr/^{86}Sr$ ratio = 0.7022 ± 0.0002, Bell, 1980). Agreement between these two age determinations is excellent. The low initial strontium ratio suggests a mantle source for the Wathaman Batholith magma.

Table 56. Rb/Sr analytical data, Hickson Lake Batholith, La Ronge Domain

Dept. No. 7508-	Rb (ppm)	Sr (ppm)	Rb/Sr (weight)	$^{87}Sr/^{86}Sr$ (atomic)	$^{87}Rb/^{86}Sr$ (atomic)
0289	81.0	433	0.187		
0290	102	354	0.288	0.72312	0.834
0291	67.2	939	0.072	0.70744	0.208
0292	74.4	701	0.106	0.70997	0.312
0292[1]	79.1	740	0.107		
0293	39.9	1110	0.036	0.70509	0.104
0294	154	163	0.945	0.77155	2.69
0295	171	185	0.924		

[1]second sample

The Hickson Lake Batholith in the La Ronge Domain gives a five-point isochron (Table 56, Figure 9) indicating an age of 1728 ± 28 Ma (Bell, 1980). The date is considered to represent igneous emplacement of the intrusion. The low initial $^{87}Sr/^{86}Sr$ ratio of 0.7024 ± 0.0001 suggests that the magma was derived mainly from the mantle.

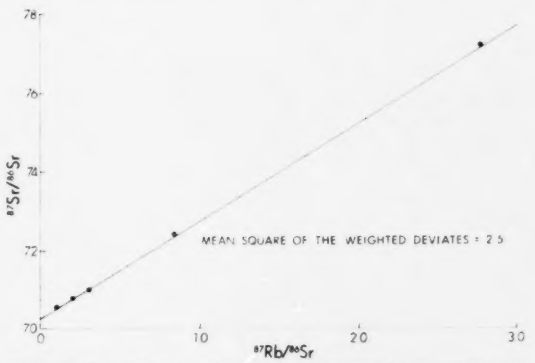


Figure 9. *Isotopic data, Hickson Lake Batholith, La Ronge Domain (Bell, 1980)*

Structural Geology

The three lithostructural domains show different tectonic styles. Consequently, each is described separately.

Wollaston Domain

In the Wollaston Domain a gneissic foliation with an accompanying schistosity (S_1) occurs in both the Archean basement and the metasediments of the Wollaston Group. Neither large- nor small-scale structures to which S_1 is axial planar have been observed. Although no definite primary bedding was seen, lithologic banding or colour banding in the gneisses and schists, possibly due to primary variations, are everywhere parallel to S_1. Hence S_1 appears to be a 'bedding foliation'.

The second generation of folds consists of upright, tight to isoclinal, noncylindrical regional structures (F_2) which in this area have shallow to moderate northeasterly plunges. The Anderson Lake antiform is typical of this fold set. Minor F_2 folds are common in Wollaston Group metasediments, particularly in the pelitic schists (Figures 10 and 11). They show axial planar schistosities defined by the parallel orientation of biotite, muscovite and locally of feldspar phenocrysts in deformed veins of porphyritic granite (Figure 12). Folds of this episode are equivalent to the third generation (D_3) folds of Lewry and Sibbald (1977).

Steeply plunging small-scale conjugate folds (F_3) which possess a subvertical axial planar crenulation cleavage (Figures 11 and 13) are rare and appear to be restricted largely to the quartz-muscovite schists (Unit 3) on the southeastern flank of the Anderson

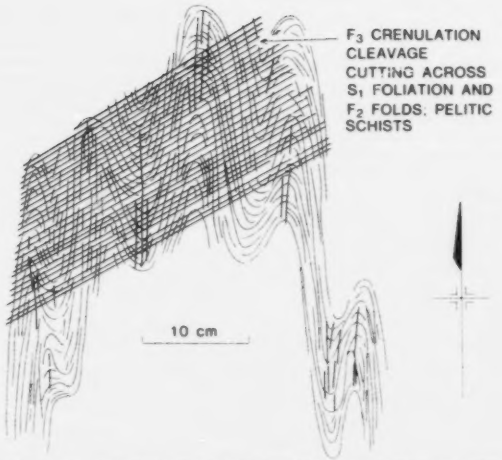


Figure 11. *Sketch showing F_3 crenulation cleavage cutting across F_2 folds, approximately 1 km north-northeast of Meg Myles Lake (56°39'28"N; 105°06'03"W)*

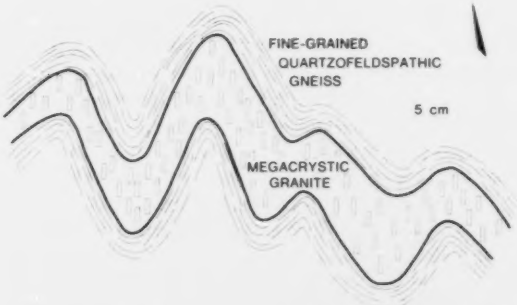


Figure 12. *Sketch showing vein of megacrystic granite emplaced within fine-grained quartzofeldspathic gneiss (Unit 5) and deformed by F_2 folds; axial planar schistosity defined by parallel orientation of feldspar phenocrysts; approximately 1 km northeast of Meg Myles Lake (56°39'23"N; 105°05'47"W)*

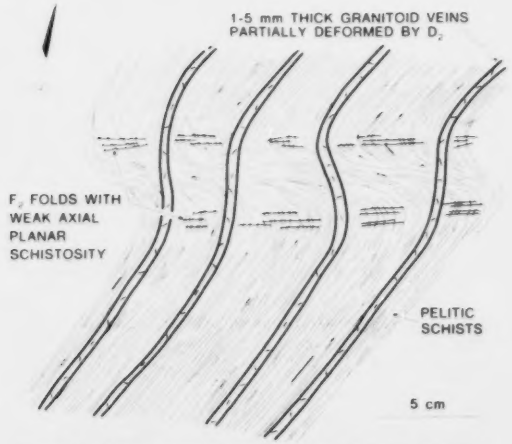


Figure 10. *Sketch showing narrow granitoid veins injected subparallel to S_1 late in the D_2 deformational event and partially folded by F_2 folds, approximately 1 km north-northeast of Meg Myles Lake (56°39'28"N; 105°06'03"W)*

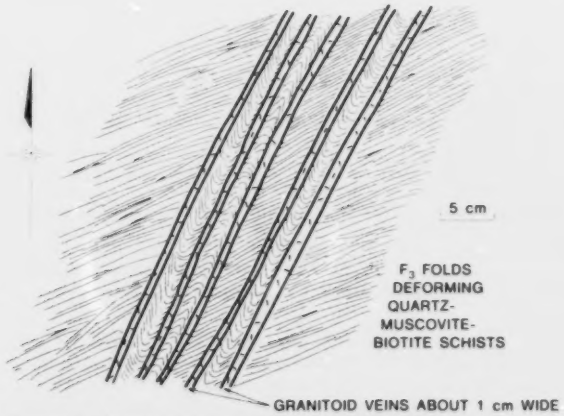


Figure 13. *Sketch showing single set of F_3 folds with granitoid veins injected subparallel to axial planes (sample 0156), approximately 1 km north of Meg Myles Lake (56°39'38"N; 105°06'20"W)*

Lake antiform. Only a single set of the conjugate folds is generally seen at any one F_3 fold locality. The axial planes of the Z set strike at 345° to 020° and those of the S set at 060° to 080°, indicating that the principal stress responsible for their development was oriented northeast-southwest. In places narrow (up to 1 cm wide) veins have been injected subparallel to F_3 axial planes; biotite, muscovite and quartz also show weak alignment parallel to these planes (0156, 0162).

Rottenstone Domain

Structural relationships in the Rottenstone Domain are unclear, partly because of the preponderance of rocks of intrusive igneous origin and partly because of the lack of distinctive marker horizons within preserved metasediments.

Evidence for an early tectonothermal event is preserved in rotated gneissose xenoliths within foliated tonalite or trondhjemite of the migmatite-tonalite/trondhjemite complex (Figure 14). The gneissosity in the xenoliths appears to have been gently folded in places prior to incorporation in the tonalite/trondhjemite (Figure 15).

Figure 14. *Sketch showing agmatite consisting of rotated blocks of medium-grained amphibole gneiss contained within foliated pegmatitic rock, western shore of Deception Lake (56° 31' 50"N; 104° 18' 45"W)*

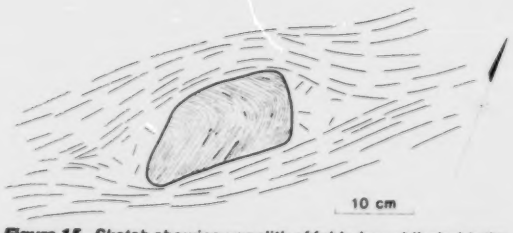


Figure 15. *Sketch showing xenolith of folded amphibole-biotite gneiss contained in foliated tonalite, small island at north end of Deception Lake (56° 34' 00"N; 104° 15' 22"W)*

Generally, however, the foliation in the paleosome of the migmatites and that in the neosomal tonalite/trondhjemite and related granitoid rocks are parallel. They have a northeasterly regional strike and are assumed to be the earliest planar fabric (S_1) recognizable throughout most of the Rottenstone Domain. As with S_1 in the Wollaston Domain, neither major nor minor folds to which S_1 is axial planar have been identified.

This early fabric has been folded into tight structures which have shallow to moderate northeasterly or more rarely southwesterly plunges. The only major F_2 structure mapped with certainty is a southwesterly plunging synform situated on the southern edge of the area 6.5 km west-southwest of Grayson Lake. Minor F_2 structures are common, especially in the migmatite and foliated tonalite/trondhjemite where biotite shows good parallel alignment to axial planes in the hinges of tight F_2 microfolds (0063, 0245) and weak alignment in open F_2 microfolds. Quartz possesses a slight dimensional preferred orientation parallel to axial planes in hinge zones. Massive or foliated granitoid veins up to 50 cm wide are locally injected parallel to axial planes of minor folds (Figures 16 and 17).

Foliated granitoid rocks are common in parts of the Wathaman Batholith (e.g. Subunit 14b). They are invariably cross-cut by massive medium- to coarse-grained equigranular biotite monzogranite or biotite granodiorite of Unit 14 (Figures 18 and 19). In places the early granitoid gneiss has been folded prior to emplacement of the massive monzogranite/granodiorite (Figure 20). It is considered that the foliated granitoid rocks are for the most part granitized equivalents of the migmatite-tonalite/trondhjemite complex (Units 10 and 11) and that the main period of emplacement of the Wathaman Batholith was post-D_2. In several places (e.g. 5 km east of Boyd Lake and around Knobel

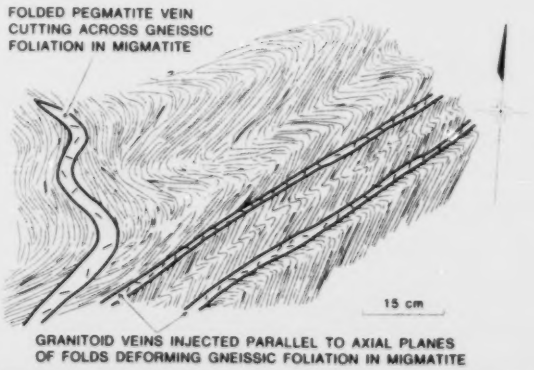

FOLDED PEGMATITE VEIN CUTTING ACROSS GNEISSIC FOLIATION IN MIGMATITE
15 cm
GRANITOID VEINS INJECTED PARALLEL TO AXIAL PLANES OF FOLDS DEFORMING GNEISSIC FOLIATION IN MIGMATITE

Figure 16. *Sketch showing relationship between gneissic foliation, F_2 folds and intrusive veins in migmatite, western shore of McDonald Peninsula, Deception Lake (56° 31' 31"N; 104° 15' 25"W)*

Lake) it appears that remnants of large-scale F_2 structures have been preserved within the main Wathaman Batholith.

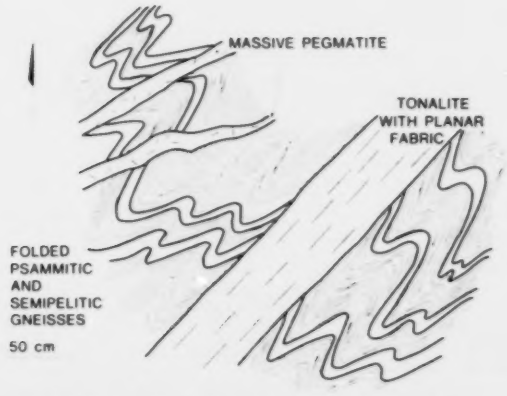


Figure 17. *Sketch showing folded psammitic and semipelitic gneisses with foliated tonalite emplaced parallel to axial planes of F_2 folds and cross-cut by veins of massive pegmatite (sample 0063), island at south end of Deception Lake (56°31'00"N; 104°17'30"W)*

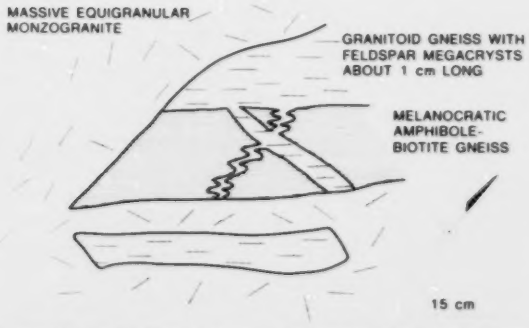

MASSIVE EQUIGRANULAR MONZOGRANITE
GRANITOID GNEISS WITH FELDSPAR MEGACRYSTS ABOUT 1 cm LONG
MELANOCRATIC AMPHIBOLE-BIOTITE GNEISS
15 cm

Figure 18. *Sketch showing xenolith of amphibole-biotite gneiss cut by granitoid gneiss containing feldspar phenocrysts about 1 cm long and by later massive equigranular monzogranite, Wathaman Batholith, island at south end of unnamed lake 6 km north of Pink Lake (56°44'13"N; 104°15'45"W)*

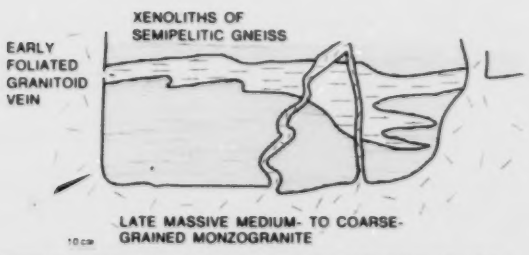

XENOLITHS OF SEMIPELITIC GNEISS
EARLY FOLIATED GRANITOID VEIN
LATE MASSIVE MEDIUM- TO COARSE-GRAINED MONZOGRANITE
10 cm

Figure 19. *Sketch showing two phases of granitoid intrusion into medium-grained semipelitic gneiss; the late massive monzogranite is typical of most of the Wathaman Batholith; 2.5 km north of Tremblay Lake (56°29'44"N; 104°42'55"W)*

No post-D_2 folds have been recognized. However, there are planar fabrics in the Wathaman Batholith, particularly towards its margins, which are of undoubted tectonic origin. These fabrics are defined by elongate quartz grains as well as by the parallel orientation of mica and of feldspar phenocrysts. They are especially well developed towards the Needle Falls Shear Zone. The change from foliated biotite monzogranite (Subunit 14b) to biotite ± hornblende granodioritic and monzogranitic augen gneiss (Subnit 15b) is gradational; the latter is thus thought to be essentially a part of the main batholith.

In the Rottenstone Domain, there is also a marked swing in the regional trend of S_1 from NNE-SSW in the southwest, to E-W in the central region around Tremblay Lake, to NE-SW in the northeast. F_2 structures appear to be affected by this swing which may have been caused by late movements along the Needle Falls and Paull River Shear Zones. No minor structures related to this large-scale warping have been identified.

The diabase (Unit 16) and the impact rocks of Calder Island (Gow Lake) are jointed but show no penetrative cleavages. Their formation undoubtedly postdates the major deformational events (D_1 and D_2). The location of the extensive Tremblay Lake diabase in the hinge area of the major post-D_2 warp suggests structural control; fractures also seem to have exerted control on diabase emplacement in some places.

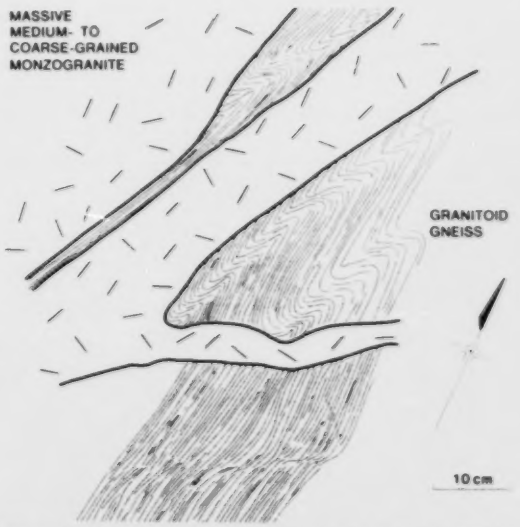


Figure 20. *Sketch showing well-foliated granitoid gneiss (locally containing xenoliths of streaked out gneisses and schists) deformed by F_2 folds and later cut by massive medium- to coarse-grained monzogranite with feldspar phenocrysts about 1 cm long, Wathaman Batholith, approximately 4.5 km east-southeast of Boyd Lake (56°24'02"N; 105°05'35"W)*

La Ronge Domain

The structural geology of the La Ronge Domain is broadly similar to that of the Rottenstone Domain.

The schistosity of the metasediments (Unit 18) is axial planar to minor isoclinal folds (F_1) which deform discontinuous narrow veins of clear quartz. No bedding has been recognized in the metasediments, so it is uncertain how these early folds affect primary layering. No major F_1 folds have been mapped.

The schistosity has been refolded about steeply plunging to subvertical axes (D_2). Axial planar fabrics are weakly developed in the metasediments, although they show a good mica lineation parallel to fold hinges. Garnetiferous granitoid veins which were injected later than but subparallel to the early S_1 foliation are folded by F_2 and show an axial planar schistosity especially in hinge zones (Figure 21). Most observed F_2 folds have wavelengths of about 1 m and are asymmetric, although a half-wavelength of about 75 m was recorded from a large fold about 8 km east-southeast of Church Island, Hickson Lake.

In the migmatite and tonalite/trondhjemite on the northwest side of Hickson Lake, F_2 folds are commonly exposed on a minor scale. They plunge steeply to the southwest or northeast. The foliated neosome is affected by D_2. Narrow unfoliated granitoid veins which cut across S_1 are also deformed by F_2 folds (Figure 22).

Needle Falls and Paull River Shear Zones

The two linear shear zones are amongst the most prominent major structures in the area. The Needle

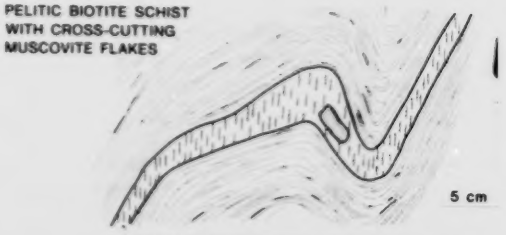

PELITIC BIOTITE SCHIST WITH CROSS-CUTTING MUSCOVITE FLAKES
5 cm
VEIN OF GRANODIORITIC MATERIAL SHOWING F_2 AXIAL PLANAR SCHISTOSITY

Figure 21. *Sketch showing muscovite-garnet leucogranodiorite vein, post-S_1, deformed by F_2 with formation of axial planar schistosity (S_2); host rocks are pelitic biotite schists (Unit 18); 0.8 km east of south end of Hickson Lake (56° 16' 28"N; 104° 17' 26"W)*

Figure 22. *Sketch showing narrow granitoid vein cutting slightly across S_1 and deformed by F_2; host rocks are pelitic schist paleosome in migmatite (Unit 10); north end of Hickson Lake (56° 20' 57"N; 104° 21' 04"W)*

Falls Shear Zone in particular is geologically important, as it separates areas of strongly contrasting lithology. Field evidence indicates that it cuts slightly across major F_2 folds, both in this and other areas along its length.

Rare folds deforming the shear fabric were seen in the mylonite (Unit 9) but not in the monzogranitic augen gneiss (Subunit 15b). Although of similar style to F_2 folds, they occur in a zone along which considerable movement has taken place and are probably not F_2 structures.

Late Fracturing and Faulting

No faults causing brecciation or major offsets of lithologic units were mapped. However, linear zones of weakness along which much erosion has occurred are obvious on aerial photographs. These lineaments interpreted as major fractures have three main orientations: north-northwest, northwest, and northeast. The last set is largely obscured on aerial photographs by the regional foliation trend.

Metamorphic Geology

As was the case with the structural geology, the three lithostructural domains have differing metamorphic mineral assemblages that require separate description.

Wollaston Domain

Mineral assemblages in the Wollaston Domain are varied, particularly in Aphebian pelites and calc-silicates (see Appendix E).

Ribbon perthite, a metamorphic feature indicative of granulite or sub-granulite metamorphic conditions, is characteristic of Archean basement granites in the map area and elsewhere in the Wollaston Domain (Ray, 1980). Hypersthene has been recorded from these rocks by (1) Money (1966) in the central part of the Pederson Lake complex west of the present area; (2) Ray (1976) in the Foster Lake (NW) - Geikie River (SW) area northwest of the present map area where it appears to be of Hudsonian age; and (3) Weber et al. (1975a) in northwestern Manitoba. However, this mineral was not identified during the present survey.

No thin sections of Aphebian metasediments have been examined in which garnet and cordierite are in stable coexistence. Ray (personal communication) reports their coexistence in Wollaston Group pelites in the Foster Lake (NE) and Geikie River (SE) areas.

The relative ages of mineral growth are difficult to establish. Biotite, muscovite, quartz, amphibole, sillimanite and cordierite-sillimanite knots show good to moderate preferred orientation parallel to S_1 in many sections. Biotite, muscovite and quartz also show preferred orientations parallel to S_2 and S_3 and/or random orientations. Where F_2 folds have been sectioned, mica in the hinge zone is deformed (0144) or has been mimetically recrystallized.

Medium to high grade metamorphism prevailed throughout the domain during M_1. In rocks of appropriate composition, growth of biotite, muscovite, sillimanite, cordierite, garnet, hornblende, quartz, microcline, plagioclase and probably tremolite and diopside is characteristic. Granitoid segregations parallel to S_1 indicate that partial melting of the metasediments took place locally, but mobilizate rarely forms more than 25 percent of the rock. Pressures are estimated to have been 3.5 to 5.5 kbars and temperatures 600 to 650°C.

The assemblages seem to have remained stable during M_2. Biotite and muscovite show orientations attributable to D_2. Other minerals (e.g. cordierite which overgrows S_1-oriented sillimanite) possess S_1 orientations but may have recrystallized mimetically during M_2. Muscovite abundance is appreciably greater southeast of Lower Foster Lake than it is north and west of the lake (e.g. near Wilt Lake). Whilst this is in part due to original rock composition, it is thought also to reflect a change in metamorphic grade. Thus, in the vicinity of Wilt Lake, muscovite has broken down by reaction with quartz and/or plagioclase.

Biotite and muscovite also developed during M_3; they are randomly oriented or in places are parallel to S_3. The style of F_3 folds suggests that the rocks were more brittle than during previous deformations. However, granitoid segregations parallel to S_3 (Figure 13) show no marginal chilling and it is thought that medium grade metamorphic conditions prevailed during M_3.

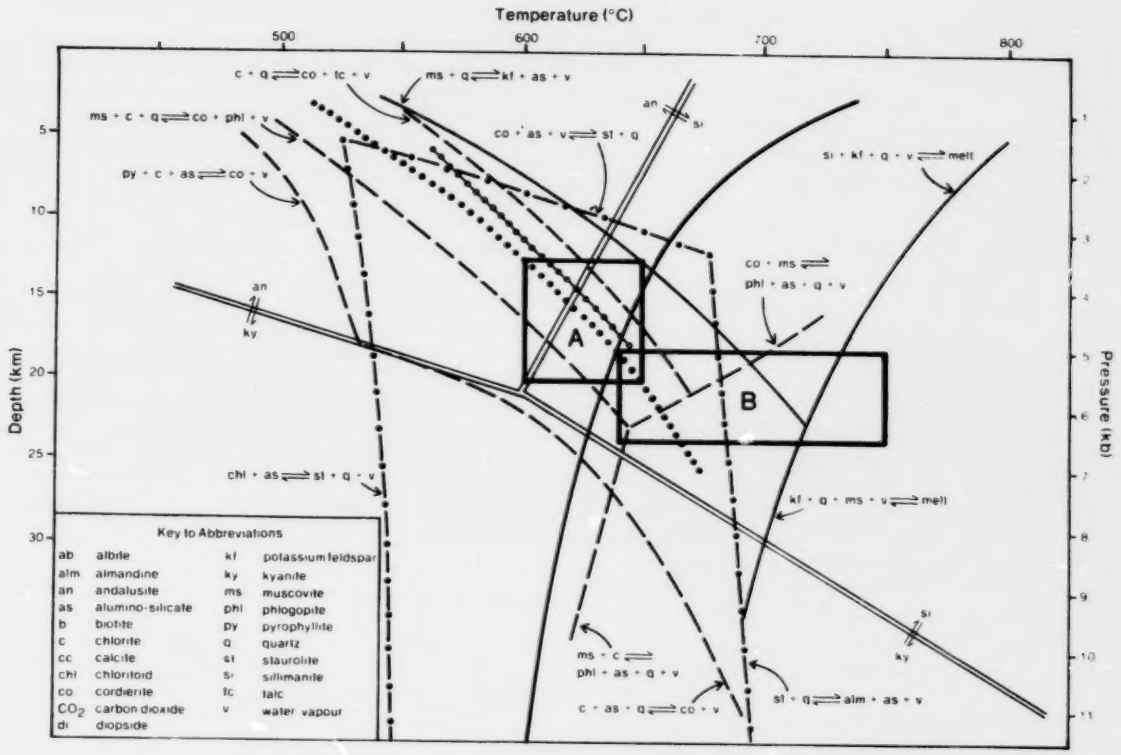
Late stage alteration is confined to widespread but weak sericitization of oligoclase and sporadic chloritization of biotite in Archean granite (Subunits 1a, b). Plagioclase alteration is also evident in amphibole-bearing rocks in the pelites (Unit 2) and in quartzofeldspathic rocks (Unit 5) northwest of the Anderson Lake antiform. Cordierite and scapolite show rare strong alteration. Later generally weak cataclasis is considered to be responsible for the almost ubiquitous straining and fracturing of quartz grains and the common occurrence of highly irregular or sutured intergranular boundaries. There is an almost total lack of granoblastic textures and triple-point junctions suggestive of annealing.

Rottenstone Domain

The Rottenstone Domain is largely made up of granitoid intrusive rocks. The paleosome of the migmatitic unit (Unit 10) includes psammites, semipelites and pelites derived from sediments, and amphibole-bearing schists and gneisses derived from intrusive and/or extrusive igneous rocks and possibly calcareous sediments. It is only within the palaeosome, therefore, that distinctive metamorphic index minerals have been formed. Mineral assemblages are given in Appendix E.

As in the Wollaston Domain, it is difficult to relate mineral growth to the three main metamorphic events. Extensive migmatization took place during the first event (M_1). This, the presence of early sillimanite and the absence of early primary muscovite or tremolite throughout the domain indicate that M_1 temperatures and pressures were about 640 to 750°C and 5.0 to 6.5 kbars respectively (Figure 23).

Biotite, amphibole and in places quartz show distinct S_1 preferred orientations; they also show S_2 (0063, 0245) or random orientations. Garnet exhibits only rare traces of an enclosed foliation (0015, 0058), possibly S_1, even though most grains are full of



Equilibrium curves for reactions involving cordierite (Schreyer and Yoder, 1964, Seifert, 1970)

Equilibrium curves defining field of Fe-rich staurolite + quartz compatibility (Richardson, 1968)*

Equilibrium curves for the alumino-silicate polymorphs (from Winkler, 1974, after Althaus, 1967, 1969 a, b and Richardson et al., 1968, 1969)

Equilibrium curve for bivariant reaction controlling first formation of diopside in metamorphism of siliceous dolomitic limestone: tr + as + q ⇌ di + v + CO_2 (from Winkler, 1974)

Equilibrium curve for the reaction st + ms + q ⇌ b + as + v (from Winkler, 1974)

Equilibrium curve determining the upper stability of muscovite in the presence of plagioclase, quartz, potassium feldspar and water vapour at pressures exceeding 3.5 kb (ab + kf + q + v ⇌ granitic melt (from Winkler, 1974, after Tuttle and Bowen, 1958 and Merrill et al., 1970)

* Richardson has suggested that the stability field of Mg-bearing staurolite + quartz is likely to be wider than that shown in the diagram and that the low pressure termination, defined by the reaction co + as + v ⇌ st + q will be significantly raised. Winkler (1974) has stated that, at pressures lower than about 5 kb, staurolite in the presence of muscovite breaks down before the upper boundary of medium grade is reached (reaction st + ms + q ⇌ b + as)

Figure 23. *Pressure/temperature diagram showing various experimentally established equilibrium curves for reactions most likely to have influenced M_1 and possibly M_2 mineral assemblages in the map area; A, medium to high grade pressure/temperature regime in the Wollaston and La Ronge Domains; B, high grade pressure/temperature regime in the Rottenstone Domain*

inclusions. Diopside presents no M_1 or M_2 distinguishing features. All these minerals may have initially crystallized during M_1, but they were stable and largely mimetically recrystallized during M_2. M_2 was also accompanied by local anatexis with segregation of partial melts along and/or parallel to F_2 axial planes (Figure 17). Muscovite was stable in the leucosyenogranite and leucomonzogranite in the presence of quartz and plagioclase. Pressures and temperatures during the second event are hence thought to be similar to those attained in the Wollaston Domain during M_1 and M_2.

M_3 gave rise to randomly oriented biotite. Muscovite, a rare accessory mineral in psammites and semipelites of the paleosome, is interleaved with and

marginally developed upon biotite and is probably of M_3 age. Most thin sections of specimens collected from the paleosome show granoblastic or subgranoblastic textures, and quartz is unstrained or weakly strained. Alteration is generally weak or absent; when present, it occurs as sericitization of plagioclase or as slight chloritization/epidotization of amphibole.

The paleosome contrasts with the neosome and with the other granitoid rocks of this domain texturally and in degree of alteration. In the granitoid rocks intergranular margins are irregular and in places sutured. Subgranoblastic textures are rare. Quartz everywhere shows moderate to intense undulose extinction and is commonly fractured. Multiple twin lamellae of many plagioclase grains are bent. Some minerals exhibit marginal break-up and recrystallization. Alteration affects mainly plagioclase (weak to strong sericitization) and biotite (weak to strong chloritization parallel to cleavage planes); amphibole and garnet where present are altered in about 50 percent of their respective occurrences.

It seems that late cataclasis, possibly associated with weak hydrothermal activity, was responsible for these observed features. Paleosomal rocks were little affected in comparison with the granitoids.

La Ronge Domain

Rocks in the La Ronge Domain include granitoids, migmatized medium-grained metasediments (Unit 10) similar to those of the Rottenstone Domain and fine-grained unmigmatized mica schists with rare interbanded amphibole-bearing horizons. Mineral assemblages are given in Appendix E.

Once again relative ages of mineral growth are difficult to establish. During M_1, rocks in the southeastern part of the domain were almost unaffected by anatexis, whereas extensive partial melting occurred in rocks to the northwest, the earliest segregations being of clear quartz. S_1 is defined by the preferred orientation of biotite, muscovite, quartz and amphibole. Sillimanite, possibly crenulated during D_2, is also considered to be an M_1 mineral. Medium to high grade metamorphic conditions are inferred, with higher grade conditions in the northwestern part of the domain.

Biotite and muscovite have crystallized parallel to S_2 where F_2 folds are developed; some flakes are also oriented transverse to S_2 (0105, 0274). Their growth either took place during and following D_2 or was entirely post-D_2 with mimetic development parallel to S_2.

Granoblastic and subgranoblastic textures indicative of late annealing are widespread throughout the metasediments of the domain, but quartz grains in places remain highly strained (0108) and show sutured boundaries (0276). Plagioclase in the amphibole-bearing rocks is highly altered; elsewhere alteration affects 50 percent of the examined sections.

Granitoid rocks of the Hickson Lake Batholith possess xenomorphic textures, slightly fractured highly strained quartz grains, and altered plagioclase occasionally with bent twin lamellae. Plagioclase in the quartz diorite/quartz monzodiorite intrusive mass is slightly sericitized, highly stained and shows much bending of twin lamellae. These features may have been produced during final stages of intrusive emplacement rather than by a later metamorphic event.

Needle Falls and Paull River Shear Zones

The early history of the shear zones is obscured by the intense post-D_2 movements that took place. In the Needle Falls Shear Zone these movements produced an abundance of ribbon-like highly strained quartz grains with sutured boundaries in the mylonite (0141, 0185; Unit 9) and augen gneiss (0188, 0315, 0316; Subunit 15b) and caused severe fracturing of feldspar porphyroclasts (0154, 0165, 0178, 0189, 0315). Tremolite in the pseudoconglomerate of Unit 9 is of possible M_2 age; the largest crystals are bent, crushed and/or strained (0155, 0178). Garnet in metasedimentary rafts in the Paull River Shear Zone is flattened and probably of M_1 or M_2 origin.

Muscovite and biotite appear to have crystallized after major movements had ceased, except in the Paull River Shear Zone where both minerals show strain effects (0103). Flakes are generally small (less than 1 mm, usually close to 0.1 mm), well oriented and probably of M_3 age. Large idioblasts of sphene in the augen gneiss (Subunit 15b) may also be of M_3 age.

Late retrogressive metamorphism is more intense in the shear zones than in the lithostructural domains. Biotite is commonly considerably chloritized, plagioclase in a few places is sericitized and hornblende in the augen gneiss is marginally altered to epidote and biotite. Recrystallization of the groundmass to give granoblastic or subgranoblastic textures is rare (0142).

The presence of albitic plagioclase in the mylonite in association with tremolite suggests low grade metamorphism prevailed during late stages of shear zone development.

Geological History

The oldest rocks exposed in the map area are monzogranites and syenogranites of Archean age. They possibly attained the sub-granulite facies of regional metamorphism prior to deposition of the Wollaston Group metasediments of Aphebian age.

The lowermost sediments of the Wollaston Group are sporadically developed conglomerate and quartzite horizons of variable thickness which crop out only in the vicinity of Jenny Lake[1] in the Wollaston Domain. These clastics were succeeded by more argillaceous sediments now occurring as pelites and semipelites of regional extent; they are commonly graphitic, particularly near their base. Clastic sedimentation followed, resulting in the widespread formation of arkosic rocks with lenses of impure carbonate in places. No higher members in the Wollaston Group succession have been recognized. Metasediments in the La Ronge Domain are probably of similar age to those in the Rottenstone Domain and are possibly Aphebian, although no conclusive evidence is currently available[2].

Two main tectonothermal events have been recognized throughout the area. They are responsible for producing penetrative foliations in the affected rocks and/or major and minor folds. Other deformational episodes are of regional and/or local importance.

The earliest event of which there is evidence produced gneissic foliation in sediments preserved as xenoliths within foliated tonalite or trondhjemite of the migmatite-tonalite/trondhjemite complex in the Rottenstone Domain.

The first tectonothermal event (D_1) of regional significance caused gneissic foliation and schistosity (S_1) to develop in supracrustal rocks of all three domains and in early tonalitic and trondhjemitic intrusives, emplacement of which either preceded or accompanied D_1. Lewry and Sibbald (1977), using models proposed by Eskola (1949) and Haller (1971), explain this earliest tectonic foliation as having developed during migmatite dome formation. They suggest that a concentric foliation is developed by flowage in marginal parts of rising gneiss domes which consist of granitoid Archean basement. At the same time bedding foliation evolves in the overlying supracrustal cover, probably by a combination of differential shear along bedding surfaces, extension around the dome and gravitational sliding.

Metamorphic grade in the Rottenstone Domain was high (640 to 750°C; 5.0 to 6.5 kbars) during D_1 and there was intense migmatization. Medium to high metamorphic grades prevailed in the Wollaston and La Ronge Domains (600 to 650°C; 3.5 to 5.5 kbars); anatectic melting was less intensive than in the Rottenstone Domain and almost nonexistent in La Ronge Domain metasediments southeast of Hickson Lake.

Similar metamorphic conditions accompanied the second regional tectonothermal event (D_2). Mineral assemblages remained stable, generally showing mimetic recrystallization, and anatexis occurred locally, the partial melts accumulating along and/or parallel to F_2 axial planes. Upright, tight to isoclinal, noncylindrical regional folds were formed in the Wollaston and Rottenstone Domains. Minor F_2 folds are common. There is evidence in the La Ronge Domain of post-D_1 pre-D_2 intrusive activity: granitoid veins cut across S_1 and are folded by F_2 with development of an axial planar schistosity in hinge zones.

The Wathaman Batholith developed largely post-D_2. Separate intrusive phases were not identified at the reconnaissance scale of this project, as the rock types are too texturally and compositionally homogeneous. The size of the batholith suggests its probable formation by a process of multiple injections. Foliated granitoid rocks appear to have been derived mainly from granitization of the host rock (the migmatite-tonalite/trondhjemite complex). Large-scale F_2 folds have been preserved in places. Shearing particularly towards the margins also produced foliations in the batholith; the northwestern edge towards the Needle Falls Shear Zone has been most intensely affected.

The age of the northeast-trending Needle Falls Shear Zone is uncertain but it has likely had a long history. Its trend and structural position are similar to those of the Virgin River Shear Zone to the west. Lewry and Sibbald (1977) propose that the earliest mylonitic fabrics recognized in the Virgin River Shear Zone are coeval with the D_1 phase of infrastructural mobilization and imply that the Needle Falls Shear Zone may also have been active at that time. On the other hand, Ray (1980) has suggested that the first movements occurred during D_2.

It is evident that the last major movements along the Needle Falls Shear Zone postdated emplacement of the Wathaman Batholith and are therefore later than D_2. This post-D_2 age is further supported by the fact

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[1]unofficial lake name

[2]Aphebian ages have been obtained by the Rb/Sr whole-rock isochron method on paragneisses from the Burntwood River Supergroup (Clark et al., 1974) and rock suites from the Amisk and Missi Groups in the Flin Flon area (Josse et al., 1974). Lithologic similarity and the delineation of the Burntwood River Supergroup and the overlying Sickle Group westwards from Manitoba to the north of Deep Bay (Gilboy, 1976), and from there southwestwards, imply the presence of Aphebian supracrustals in the La Ronge Domain.

that the shear zone cuts slightly across major F_2 folds.

No evidence for the age or sense of relative movement of the simlilarly trending Paull River Shear Zone has been observed. However, no undoubted F_2 folds were seen within the shear zone, so it is probably the same age as the Needle Falls Shear Zone. The broad Z-shaped swing in regional S_1 trends in the Rottenstone Domain may be genetically related to the shear zones.

A third tectonothermal event (D_3) generated steeply plunging small-scale F_3 conjugate folds recognized only in quartz-muscovite schists of the Wollaston Domain. F_3 fold orientation indicates principal stresses were directed from the northeast and southwest. In all three domains randomly oriented flakes of biotite and muscovite are considered to be M_3 metamorphic minerals. Granoblastic and subgranoblastic textures were produced in places in metasedimentary rocks. Time relationships between this event, the emplacement of the Wathaman Batholith and the final major movements along shear zones remain uncertain.

Late stage weak cataclasis possibly associated with final movements along shear zones is indicated by the widespread occurrence in all three domains of strained and fractured quartz grains, plagioclase

Table 57. Summary of the geological history of the map area

			Wollaston Domain	Needle Falls Shear Zone	Rottenstone Domain	Paull River Shear Zone	La Ronge Domain
QUATERNARY			EROSION GLACIATION				
? PHANEROZOIC			EROSION ? Jointing		Jointing Meteorite impact		? Jointing
PRECAMBRIAN			UPLIFT AND EROSION				
	? HELIKIAN		Faulting and fracturing		Emplacement of diabase Fracturing and faulting		Fracturing and faulting
	HUDSONIAN OROGENY (c. 1700 to 1900 Ma)		Weak regional cataclasis and retrogressive metamorphism		Weak regional cataclasis and retrogressive metamorphism; formation of the broad Z-shaped warp bounded by the shear zones		Weak regional cataclasis and retrogressive metamorphism
		D_3	Randomly orientated biotite and muscovite, and granoblastic and subgranoblastic textures developed after deformation had ceased Steeply plunging conjugate folds indicating principal stresses from northeast and southwest; axial planar crenulation cleavage (S_3); biotite, muscovite and quartz weakly aligned parallel to S_3; narrow granitic veins; medium grade metamorphism	?	Randomly oriented biotite and muscovite, and granoblastic and subgranoblastic textures formed Emplacement of Wathaman Batholith, probably by multiple injection	?	Randomly oriented biotite and muscovite, and granoblastic and subgranoblastic textures common in metasediments in the southeast Emplacement of Hickson Lake Batholith
		D_2	Upright, tight to isoclinal, non-cylindrical, northeast-trending regional folds; minor folds commonly show well-developed mica schistosity in hinge zones; narrow granitoid veins injected subparallel to S_1 and partially folded; M_1 minerals stable during M_2 but recrystallized; metamorphic conditions: 3.5-5.5 kb, 600-650° C Localized emplacement of porphyritic granite veins	?	Upright, tight to isoclinal, non-cylindrical, northeast-trending regional folds; minor folds commonly show well-developed mica schistosity in hinge zones; deformation accompanied by local anatexis, giving granitoid veins along and/or parallel to F_2 axial planes; M_1 minerals stable but recrystallized; metamorphic conditions: 3.5-5.5 kb, 600-650° C Emplacement of leucosyenogranite and leucomonzogranite bodies	?	Minor folds with subvertical axial planes (S_2) and steeply plunging to subvertical hinges; biotite and muscovite oriented parallel to S_2; metamorphic conditions: 3.5-5.5 kb, 600-650° C ? Emplacement of quartz diorite/body quartz monzodiorite Emplacement of leucogranodiorite and related granitoids, mainly as veins
		D_1	Gneissic foliation (S_1), possibly a bedding foliation formed by migmatite doming, imparted to granitic basement and Aphebian metasediments; some anatectic melting; metamorphic conditions: 3.5-5.5 kb, 600-650° C Emplacement of sheet-like monzogranite	?	Foliation (S_1) imparted to tonalite and trondhjemite, generally parallel to foliation in adjacent metasediments; anatectic melting; metamorphic conditions: 5.0-6.5 kb, 640-750° C Emplacement of tonalite and trondhjemite bodies ? Emplacement of ultramafic masses	?	Foliation (S_1) imparted to granitoid intrusive rocks and to host metasediments; quartz veins folded with S_1 axial planar schistosity; metamorphic conditions: 3.5-5.5 kb, 600-650° C Emplacement of tonalite and trondhjemite bodies
	KENORAN OROGENY (2600 Ma)		Aphebian sedimentation UPLIFT AND EROSION Archean granitic basement, possibly metamorphosed to sub-granulite facies	?	? Gneissic foliation gently folded ? Gneissic foliation imparted to sediments ? Aphebian sedimentation	?	? Segregation of narrow discontinuous veins of clear quartz ? Aphebian sedimentation

crystals with bent multiple twin lamellae and highly irregular or sutured intergranular boundaries. Late stage alteration such as sericitization or saussuritization of plagioclase, chloritization of biotite and breakdown of amphibole is common but unevenly distributed, concentrating in granitoid rocks. It was probably caused by weak hydrothermal activity during the late stages of Wathaman/Hickson Lake Batholith emplacement and/or the regional weak cataclasis. Late retrogressive metamorphism is more intense in the shear zones than in the lithostructural domains.

All events from D_1 to the late stage alteration are probably associated with the Hudsonian orogeny.

The final structural event of regional significance was late fracturing and faulting. The age of these fractures is uncertain, although field evidence indicates that they cut all other geological structures and Precambrian lithologies. Fractures and the broad Z-shaped swing of foliation trends both appear to have exerted control on emplacement of the Tremblay Lake diabase. The north-northwesterly trending set of fractures which cuts the diabase body either postdates the diabase body either postdates the diabase or was a preexisting fracture set that was reactivated following diabase intrusion.

The impact-produced dacitic rocks of Calder Island in Gow Lake are jointed but show no penetrative fabrics. They are unaffected by any of the regional metamorphic events. Thomas and Innes (1977) have suggested a speculative minimum age of 100 Ma for the impact event.

During the Quaternary the area was covered by ice sheets which have left thin veneers of glacial till between thicker deposits of glaciofluvial sands and gravels. Five main esker systems are evident in the map area; they are in places flanked by sand plains derived by late and post-glacial erosion.

The geological history of the area is summarized in Table 57.

Economic Geology

Except in the broad vicinity of the Rottenstone Mine in the Rottenstone Domain, mineral exploration in this area has been concentrated in the Wollaston and La Ronge Domains. All numbers in parentheses after company names refer to Assessment File Reports, Saskatchewan Mineral Resources, Regina.

Wollaston Domain

Radiometric, geochemical, magnetic and conductivity anomalies are numerous and have resulted in detailed company exploration work supported by drilling and trenching programs. No new areas of economic interest were found during the present survey. Results of this work are summarized below.

Sico Mining Corporation Limited, 1960 (74A11-NE-0014). An electromagnetic/magnetic survey (3,574 line miles) over parts of the Wollaston and Rottenstone Domains located seven main conductor systems in the Wollaston Domain and three in the Rottenstone Domain. One conductor in the Wollaston Domain was drilled. On the northwestern shore of Meg Myles[1] (Teebee[1]) Lake a diamond-drill hole intersected disseminated pyrite/pyrrhotite in grey-blue fine-grained graphite-bearing schists from 60.5 to 77 m below surface. Assayed samples yielded only trace amounts of gold and silver.

Milldale Minerals Limited, 1961 (74A11-NE-0001). Magnetic and electromagnetic ground surveys were carried out 3 to 4 km south-southwest of South Burbidge Lake[1] to determine the location and character of two conductors and magnetic anomalies picked up by a previous aerial geophysical survey. One diamond-drill hole was sunk to test each conductor. The first encountered disseminations of pyrite and pyrrhotite (up to 15 percent of the rock) in graphite-bearing schists between 57 and 74.7 m. The second hole cut through mylonite (rhyolite as described in the file) for most of its length; up to 15 percent pyrite was found between 34.1 and 35.1 m.

Great Plains Development Company of Canada Limited and Bomarc Mining Company Limited, 1969-70 (74A10-NW-0002, 74A11-NE-0033). Geological surveys and prospecting work were carried out between the north end of Lower Foster Lake and Macpherson Lake, primarily as a follow-up to an airborne radiometric survey by Questor Surveys Limited. Preliminary assay results indicated that radioactivity in an anomalous zone at the contact between metasediments and the Archean basement monzogranite/syenogranite is due to a high thorium content (up to 1.1 percent ThO_2), whereas an anomaly within the basement rocks is due to relatively high uranium (up to 0.25 percent U_3O_8) contained as uraninite in biotite crystal lattices in pegmatites. Several trenches were blasted in 1969; molybdenum was reported from one of these in the basement monzogranite/syenogranite, with assayed samples giving 0.04 to 0.12 percent Mo and 0.033 to 0.512 percent U_3O_8.

Six diamond-drill holes were sunk about 1 km north-northwest of Kostyshyn (Babyloon[1]) Lake in 1969 and three more were put down in the following year. Their depths varied from 5.5 to 168.6 m. Biotite gneiss (Unit 2), locally garnetiferous, was the main rock type encountered; pegmatitic bands were common. Graphite-bearing horizons were abundant, especially in the drill hole closest to the basement contact. Core containing disseminated pyrite (up to 15 percent) with local traces of chalcopyrite was recovered. Assays fell within the following ranges: 0.001 to 0.077 percent U_3O_8, 0.03 to 0.13 percent ThO_2, 0.002 to 0.04 percent Cu, 0.005 to 0.009 percent Pb, 0.003 to 0.004 percent Zn, 0.009 percent Ni and 0.03 ounce of Ag per ton.

Anglo-Bomarc Mines Limited, 1971 (74A11-NE-0035, 0037, 0038). In 1971, in an area immediately to the northeast of Grandi Lake, Anglo-Bomarc carried out geological mapping and soil sampling (analyzed for Pb) programs, assayed numerous hand specimens for Au, Ag, Pb, Zn and Cu, and measured gamma radioactivity with a scintillometer. A lead anomaly was detected from the soil survey and a sample of metasediment returned a moderate zinc assay. In 1972 further mapping and soil sampling (analyzed for Pb, Zn and Cu) was conducted immediately northwest of the area surveyed in 1971. The 1971 samples were reanalyzed for copper and zinc. Copper values were of negligible interest but the main zinc anomaly showed good correlation with the previously established lead anomaly.

Further work was carried out in 1974 to determine the cause of the lead/zinc anomaly and to evaluate further by geological mapping the base metal and uranium potential of the area. The rock type of most economic interest was inferred to be a horizon of impure biotite quartzite containing 1 to 5 percent pyrite and minor pyrrhotite. This horizon (Unit 3) is thought to contain sporadic occurrences of sphalerite.

Department of Northern Saskatchewan, 1975 (7A11-SE-0039). Line-cutting, geophysics and reconnaissance and detailed geology surveys were carried out to investigate a copper showing situated 400 m west of the southwestern end of Astleford Lake. The mineralization occurs in grey to dark grey

[1]unofficial lake name

[1]unofficial lake name

quartzite within meta-arkose at the contact between mylonite (Unit 9) and quartzofeldspathic rock (Unit 5). Magnetic responses are caused by disseminated pyrrhotite in interbanded quartzites and felsic gneisses. Weak conductors in the vicinity are due to disseminated pyrite with trace amounts of graphite. Two trenches which were blasted to test the original copper showing encountered pyrite, pyrrhotite, arsenopyrite, chalcopyrite and cobalt bloom. A third, put down to test a parallel gossan zone to the east, encountered only pyrite and pyrrhotite. The best assays from the showing were 0.25 percent Cu, 1.22 percent Co, 0.66 ounce of Ag per ton and a trace of gold. The occurrence was considered too small and too low grade to warrant further work.

Department of Mineral Resources, Saskatchewan and Department of Energy, Mines and Resources, Canada, 1976 (GSC Open File 311). Parts of flight lines 13 to 17 inclusive (east-west lines flown with 5 km line spacing at a mean terrain clearance of 130 m) of an airborne gamma-ray spectrometry survey carried out in 1975 are over the Wollaston Domain in this map area. Contour maps were produced for the total count, potassium, equivalent uranium and equivalent thorium concentrations, and for eU/eTh, eU/K and eTh/K ratios.

The equivalent uranium map shows four uranium highs, one of 1.4 ppm, one of 1.6 ppm and two of 1.8 ppm. One of the 1.8 ppm anomalies is situated over Archean basement monzogranite/syenogranite (Subunit 1b) southeast of the northern end of Lower Foster Lake, while the second occurs over quartz-muscovite-biotite schist (Unit 3) in the hinge of the Anderson Lake antiform. Of the two highest recordings, one is centred close to a calc-silicate lens within quartzofeldspathic rock (Unit 5) 4 km north-northeast of Brady Lake[1], while the other occurs in pelitic biotite schists and gneisses (Unit 2) 2 km south-southwest of Split Lake[1]. The first two anomalies have been examined by Great Plains Development Company of Canada Limited (see above). The anomalous area south-southwest of Split Lake[1] has also been examined by Great Plains; the radioactivity was predominantly confined to the foliated monzogranite (Unit 8) and associated pegmatites but no visible mineralization was reported.

Rottenstone Domain

The Rottenstone Domain contains the only worked orebody in the area. Originally known as the Hall showing, it was mined from 1965 to 1968. A reported 28,724 tons of copper-nickel-palladium-platinum-gold-silver ore were hoisted, providing 5,564 tons of concentrate. A considerable amount of exploration work has been carried out around the mine, resulting in the location of conductor horizons, many of which have been drilled. All known mineralization is confined to the migmatite-tonalite/trondhjemite complex. The following is a summary of work carried out in this domain.

Consolidated Mining and Smelting Company of Canada Limited, 1928. Fifteen diamond-drill holes were put down into the Hall showing. Four holes were also drilled into the Red Hill rust zone at the northern end of Rottenstone Lake but with negligible results.

Manitoba Basin Mining Company, 1928-29. Pyrrhotite showings in the Rottenstone Lake area were trenched.

Canadian Department of Mines and Resources, 1946 (Mawdsley, 1946). An area of 52 km^2 around Rottenstone and Lower Rottenstone Lakes was geologically surveyed by Mawdsley, with special attention given to the Hall and nearby Tremblay-Olson showings. The host rocks in both places are serpentinized ultramafics. Large enstatite crystals are present at the Tremblay-Olson showing. The Hall occurrence contains up to 50 percent sulphides in the form of pyrrhotite and lesser chalcopyrite. A whitish mineral (in reflected light) associated with the pyrrhotite/chalcopyrite was identified as violarite. Very rare tiny blebs of pentlandite were reported. Similar sulphide mineralogy was described from the Tremblay-Olson showing.

Cape Copper Mines Limited, 1951-53 (74A07-SW-0004) drilled 14 X-ray diamond-drill holes around the Hall showing and carried out a ground magnetometer survey over this and the Tremblay-Olson showing.

Trans-Dominion Mining and Oils Corporation, 1954 (74A07-SW-0001) picked up the Hall property and the surrounding Cape Copper ground. Nineteen diamond-drill holes were put down on the Hall showing and nearby magnetic anomalies.

Sico Mining Corporation Limited, 1957-61 (74A07-SW-0007, 0017, 74A07-NE-0019, 74A10-SW-0005, 74A11-NE-0014). Early work included drilling of the Hall showing (nine holes) and trenching of a pyrrhotite zone to the northeast. Prospecting in an area immediately west of Rottenstone Lake revealed coarse biotite-quartz gneiss with up to 25 percent pyrrhotite, minor graphite and rare veinlets of chalcopyrite.

An airborne electromagnetic survey located three conductors of interest, all of which were drilled. The only conductor to return mineralization, located between Kellogg Lakes and Bachmeier Lake, contained low concentrations of pyrite and pyrrhotite. Four drillholes were also sunk to intersect

[1]unofficial lake name

possible continuations along strike of the Tremblay-Olson showing; the only ultramafic rock found was 2.25 m of pyroxenite encountered at depth in a 130 m hole.

Milldale Minerals Limited, 1961 (74A07-SW-0003) sank two drillholes close to the Tremblay-Olson showing but failed to find any continuation of the ultramafic rock.

Rottenstone Mining Limited, 1965-68 (Richards and Robinson, 1966) worked out the Hall orebody. Original plans appeared to include also the working of the Tremblay-Olson showing but these were never realized. In addition to the pyrrhotite, chalcopyrite, violarite and minute amounts of pentlandite described by Mawdsley (1946), other associated minor ore minerals included sperrylite, sphalerite, cubanite and magnetite.

Sherritt Gordon Mines Limited, 1967-68 (74A07-NW-0010, 0011, 0013, 0021, 74A07-SW-0009) flew airborne electromagnetic and magnetic surveys over much of Saskatchewan. A few of the resulting anomalies were followed up on the ground with detailed electromagnetic and magnetic work and diamond-drilling. Nine holes were drilled on four conductors, all of which yielded zones containing up to 50 percent pyrite/pyrrhotite. Chalcopyrite was rarely observed.

Scurry-Rainbow Oil Limited, 1969 (74A07-NE-0014) carried out airborne electromagnetic, magnetic and scintillometer surveys over a 1300 km^2 area near Gow and Deception Lakes. The numerous conductors found were considered to be due to pyrrhotite- and/or pyrite-bearing horizons.

Canadian Occidental Petroleum Limited, 1972-73 (74A07-SW-0024, 0025) was responsible for an airborne electromagnetic/magnetic survey and for geological, lake silt geochemical and Pleistocene surveys. Numerous conductive zones were found, some of which were new; selected conductors were checked in the field. Detailed ground work was carried out on two isolated magnetic highs close to Rottenstone Lake. Two diamond-drill holes located disseminated magnetite in sufficient concentrations to account for the anomalies. A third drillhole put down to test a conductive horizon northeast of Rottenstone Lake revealed syngenetic pyrrhotite-pyrite mineralization in metasediments; the best assay was 0.09 percent Cu and very low Ni.

Department of Mineral Resources, Saskatchewan and Department of Energy, Mines and Resources, Canada, 1974 (GSC Open File 266). About 225 sediment samples were collected from numerous lakes in the Rottenstone and La Ronge Domains in this area and analyzed for Fe, Cu, Pb, Zn, Ni, Ag, Mn, Mo, Co, As, U and loss-on-ignition as part of a national geochemical reconnaissance project. Iron shows anomalous concentrations of 10 to 50 percent in many samples from the southwestern quarter of the map area. Isolated anomalous values occur elsewhere but are rare. Copper shows no large anomalies, having concentrations of 10 to 50 ppm, except in the southwest quarter where concentrations of 50 to 100 ppm are numerous. Lead values are consistently low but tend to differentiate well between the Wathaman Batholith (less than 1 ppm) and the migmatite-tonalite/trondhjemite complex (2 to 10 ppm). Zinc has uniform values of 20 to 120 ppm with a tendency towards the higher end of this range in the southwest. Nickel like lead shows slight differences in concentration between samples collected over the Wathaman Batholith (0 to 20 ppm) and those over the migmatite-tonalite/trondhjemite complex (5 to 100 ppm). There is one coincident copper-nickel high value from a lake 2.4 km northwest of Rottenstone Lake (drilled by Sherritt Gordon Mines Limited). Silver values are mostly less than 0.2 ppm; several values in the range 0.2 to 1 ppm occur in lakes 5 to 10 km south and east of Dobbin Lake and in the southwest corner of the area. Manganese values show random distribution with a slight tendency towards higher concentrations (up to 5000 ppm, one value of 20 000 ppm) in the southwest. Molybdenum values range from 0.5 to 10 ppm and show an even distribution. Cobalt (0.5 to 50 ppm) shows some concentration in the southwest but no major anomalies are present. Arsenic occurs in low concentrations (generally 0.2 to 0.5 ppm) over the Wathaman Batholith; concentrations increase southeastwards (0.2 to 5 ppm) over the migmatite-tonalite/trondhjemite complex. Uranium (0.1 to 10 ppm) is evenly distributed with most values falling in the range 2 to 5 ppm. Two high values were recorded, one (20 ppm) 3 km north of Tremblay Lake, the other (50 ppm) 11 km north-northwest of the same lake. Loss-on-ignition usually exceeds 10 percent.

Present reconnaissance geological survey, 1975. Several previously undescribed sulphide occurrences were discovered; one of these, located 300 m southeast of the narrows separating the two McLellan Lakes, consists of pyrrhotite/pyrite with minor chalcopyrite in a greenish grey amphibole-diopside-biotite gneiss.

Department of Mineral Resources, Saskatchewan and Department of Energy, Mines and Resources, Canada, 1976 (GSC Open File 311). Parts of flight lines 7 to 18 inclusive of an airborne gamma-ray spectrometry survey covered the Rottenstone Domain in this area. On the total count map, an anomalous low of 400 counts per second (cps) is situated over Deception Lake. Otherwise all values are in the range 1000 to 1800 cps. Equivalent uranium and equivalent thorium values are

consistently low. Fluctuations in potassium are gentle and small; values tend to be slightly higher over the Wathaman Batholith (1.6 to 2.2 percent potassium) than over the migmatite-tonalite/trondhjemite complex (0.8 to 1.8 percent). The Needle Falls and Paull River Shear Zones show up extremely well especially on the equivalent uranium map.

La Ronge Domain

Visible sulphide mineralization appears to be limited to the pelitic metasediments (Unit 18) of this domain. Two polished sections of the mineralization were examined. Section 0269 contains about 5 percent small (up to 0.5 mm) irregularly shaped pyrrhotite grains in both disseminations and veins; rare disseminated grains have bands of chalcopyrite. Iron oxide minerals are also present. Section 0274 contains about 5 percent pyrite; most grains have a core of an unidentified mineral or, where this mineral has been replaced, a pyrite core zone full of dusty inclusions surrounded by inclusion-free margins. A trace of chalcopyrite is marginally associated with a very few pyrite grains and occurs as discrete crystals. Subidioblastic magnetite up to 0.1 mm across is also present.

The following is a summary of the mineral exploration work carried out in the domain.

Don Fisher Syndicate, 1965-67 (74A08-SE-0002) examined two small aeromagnetic anomalies about 1.5 km east of Hickson Lake which had been selected from the Federal-Provincial map (2823G). Electromagnetic and magnetic surveys, trenching and a geochemical soil sampling program were carried out, and assays for Au, Ag, Cu, Ni and Pb were made of grab samples from some of the trenches. Pyrrhotite occurrences with minor amounts of pyrite and marcasite were abundant. The assays returned negative results. No radioactive zones of interest were encountered.

Lytton Minerals Limited, 1968 (64D12-NE-0004). Magnetic and electromagnetic surveys were carried out over an area on the southeastern side of Hickson Lake. Concurrent scintillometer, geochemical soil sampling and geological mapping programs were reportedly undertaken. Ten radioactive showings and one sulphide occurrence were located but none proved to be of economic significance.

Department of Mineral Resources, Saskatchewan and Department of Energy, Mines and Resources, Canada, 1974 (GSC Open File 266). The national geochemical reconnaissance project mentioned previously also covered the La Ronge Domain in this area. Iron does not exceed 10 percent in samples collected from the La Ronge Domain. Copper values are less than 50 ppm; most samples in the 20 to 50 ppm range are from lakes underlain by pelitic metasediment (Unit 18, Subunit 18a). Lead values are low; the higher concentrations (2 to 10 ppm) appear to be in areas underlain by migmatite (Unit 10) or pelitic metasediment. Zinc values of 100 to 120 ppm occur over terrain occupied by pelitic metasediments, whereas elsewhere in the domain they are 20 to 100 ppm. Nickel concentrations (5 to 50 ppm) are randomly distributed. Silver values are low, most being less than 0.1 ppm. Manganese is randomly distributed, concentrations being in the range 100 to 5000 ppm. Molybdenum (0.5 to 5 ppm), cobalt (0.5 to 20 ppm) and arsenic (0.2 to 5 ppm) are evenly distributed. Uranium yields the most interesting results with two high values (50 to 100 ppm) over the Hickson Lake Batholith. Several other values greater than 10 ppm have been obtained from the batholith. One of the high anomalies 4 km northeast of Hickson Lake is coincident with a major anomaly found during the airborne gamma-ray spectrometry survey in 1975.

Present reconnaissance geological survey, 1975. No showings of economic interest were found. The sulphide occurrences mapped contain only trace amounts of chalcopyrite and occur in graphitic pelites and amphibolites in the metasediments 1.5 km east of Hickson Lake (i.e. in the same area as the occurrences investigated by the Don Fisher Syndicate and Lytton Minerals Limited).

Department of Mineral Resources, Saskatchewan and Department of Energy, Mines and Resources, Canada, 1976 (GSC Open File 311). Parts of flight lines 7 to 10 inclusive of an airborne gamma-ray spectrometry survey were over the La Ronge Domain in the map area. Two interesting anomalies are found on the total count map. One of 2000 cps is located 4 km southeast of Grayson Lake; the other of 1800 cps is 3.5 km northeast of Hickson Lake. Both anomalies are coincident with major equivalent uranium anomalies of 2.6 and 2.4 ppm respectively. A third important equivalent uranium anomaly of 2.0 ppm is situated 1 km west of Hickson Lake. The first two anomalies show weakly on the potassium map; only the first shows on the equivalent thorium map where it is also very weak. The anomalies southeast of Grayson Lake and west of Hickson Lake are hosted by tonalite/trondhjemite in or next to the Paull River Shear Zone. The other anomaly is centrally situated within a monzogranitic lobe of the Hickson Lake Batholith.

Summary and Conclusions

Most sulphide occurrences in the supracrustal rocks of all three domains are stratabound. They are largely

syngenetic though later concentration into veins has taken place on a small scale. This type of mineralization has proved to be economically disappointing. The rich but small Rottenstone ore deposit occurred in ultramafic rock which appeared to have injected adjacent metasediment prior to granitoid emplacement of probable D_1 age.

Uranium anomalies in the Wollaston Domain are associated with pegmatite in Archean basement, the sheet-like monzogranite and associated pegmatites, pegmatitic bands in graphitic garnetiferous biotite gneiss close to the Aphebian/Archean contact and possibly carbonate rocks in meta-arkose; nowhere has the element been fo· ıd in economic abundance. The age and genesis of tt.ese occurrences have not been investigated.

Other radiometrically anomalous areas have been previously detected and checked out. However, an anomaly in the La Ronge Domain (3.5 km northeast of Hickson Lake) should receive further attention, as the area was visited only briefly during exploration traverses by Lytton Minerals Limited.

Apart from ground checking of several radioactive (uranium) highs apparent on maps of the Federal-Provincial airborne gamma-ray spectrometry survey, further exploration work in the map area is unlikely to yield worthwhile results.

The radioactive highs deserving investigation are:

a) 4 km north-northeast of Brady Lake[1] in the Wollaston Domain where the geology suggests the possibility of a Burbidge Lake type of uranium deposit;
b) 4 km southeast of Grayson Lake where uranium mineralization if present might be genetically associated with the Paull River Shear Zone; and
c) 1 km west of Hickson Lake where again possible uranium mineralization might be controlled in some way by the Paull River Shear Zone.

[1]unofficial lake name

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Appendix A: Terminology

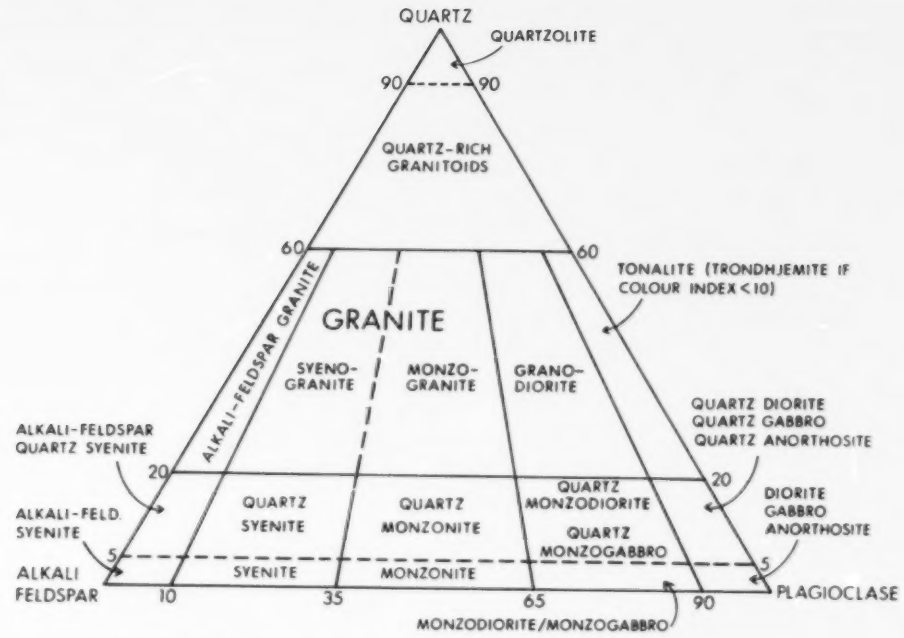

Figure 24. *General classification and nomenclature of plutonic rocks (IUGS recommendation, Streckeisen, 1976)*

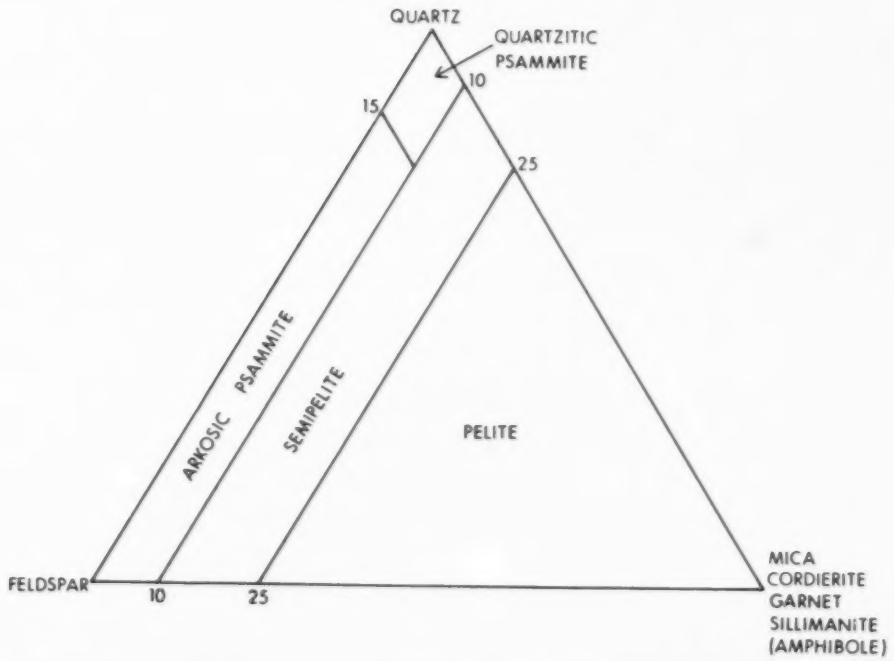

Figure 25. *General classification and nomenclature of metasedimentary rocks*

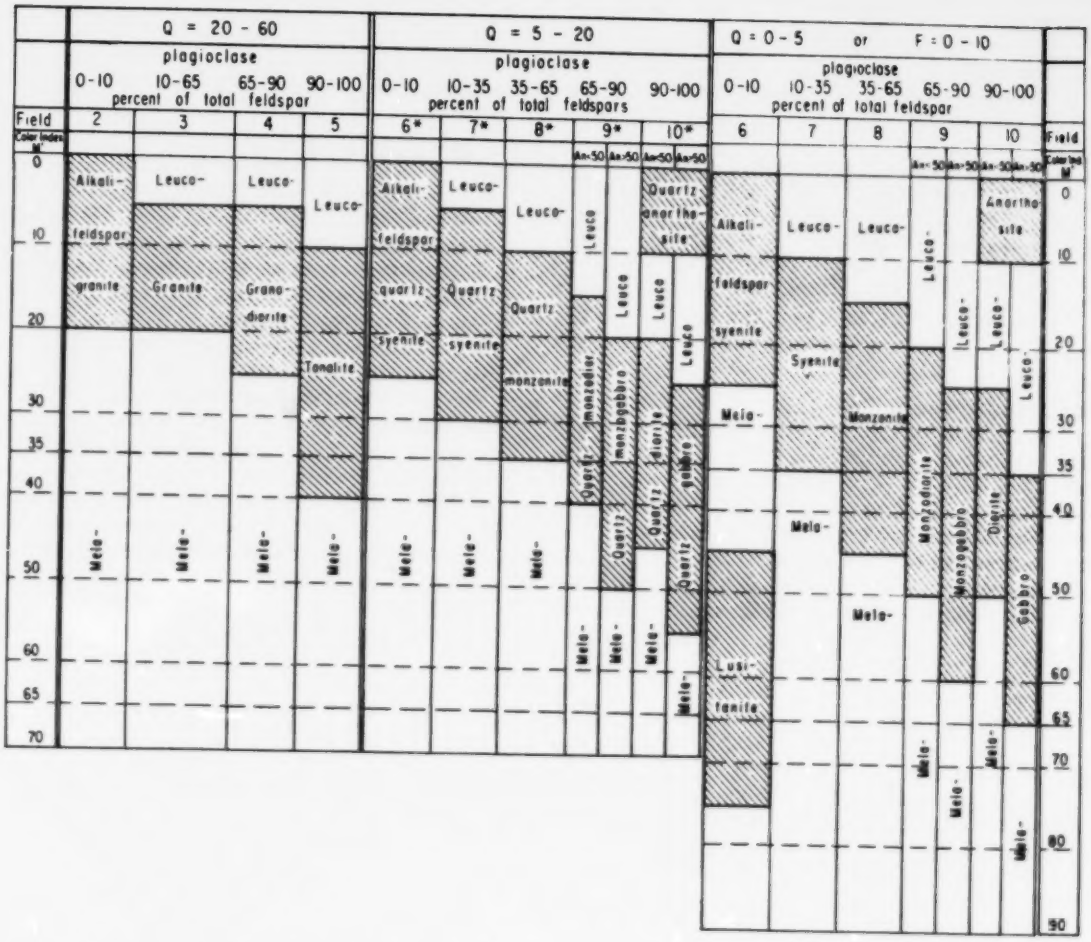

Figure 26. *Mafic mineral content of the various plutonic rock types (IUGS recommendation, Streckeisen, 1976)*

Appendix B: Abbreviations and Symbols Used in Modal Composition Tables

Act	Actinolite
Al	Allanite
Ant	Anthophyllite
Ap	Apatite
Bt	Biotite
Cbt	Carbonate
Chl	Chlorite
Co	Cordierite
Cz	Clinozoisite
Di	Diopside
Ep	Epidote
Gr	Graphite
Gt	Garnet
Hb	Hornblende
Ms	Muscovite
Op	Opaque minerals
Qz	Quartz
Ru	Rutile
Se	Sericite
Si	Sillimanite
Sph	Sphene
To	Tourmaline
Tr	Tremolite
Zo	Zoisite
Zr	Zircon
||	Dimensional orientation parallel to S_1
#	Dimensional orientation parallel to S_2
⋕	Dimensional orientation parallel to S_3
=	Weak dimensional orientation parallel to S_1
x	Random orientation
∫	Mineral oriented transverse to S_2
○	Garnet full of inclusions
◊	Garnet lacking inclusions
*	Mineral weakly altered
**	Mineral extensively altered
(ap)	Antiperthitic lamellae of potassium feldspar in plagioclase
(s)	String or ribbon perthite
(p)	Patch perthite
	exsolution of or replacement by plagioclase in potassium feldspar
An_{60}	Plagioclase composition in terms of anorthite content (determined by the Michel-Levy method)

Appendix C: Geochemical Sample Preparation and Analytical Methods

Samples were initially broken up with a hammer and then passed through a jaw crusher (with carbon steel jaws to eliminate Ni, Cr or Co contamination) which reduced them to chips of 0.5 cm or less. This material was quartered, the larger fraction being stored and the smaller fraction crushed to -120 mesh in a Spex shatterbox mill.

Approximately 3 g of the powder was heated at 120°C for 8 hours in preheated vitreosil crucibles and then at 950°C for a further 8 hours. The weights at these temperatures were used to determine hygroscopic water (H_2O^-)and loss-on-ignition (LOI) respectively. Small portions (0.28 g) of the ashed sample material were used to make fusion discs for major element analysis according to the method of Norrish and Chappell (1967). The flux used was Chemplex Grade III X-ray fusion flux (catalogue no. 925) consisting of 47 percent lithium tetraborate, 37 percent lithium carbonate and 16 percent lanthanum oxide. All major elements (or oxides) except for sodium and phosphorus were determined on the fusion discs using a Philips PW 1540 manual spectrometer with a 2 KW generator. Ferrous iron was determined titrimetrically using the method outlined by Hutchison (1974).

Approximately 6 g of powder was moistened with a 1 percent PVA solution to improve cohesive qualities of the oversaturated rocks and briquetted in Spex aluminum cups (catalogue no. 3619) at a pressure of 12 tons. Sodium, phosphorus and all trace elements were determined on these whole rock powder pellets using the same spectrometer.

All analyses were carried out in duplicate and sets of international standards were determined at least 4 to 6 times during any particular run. In order to obtain a quantitative check on precision in instrument operation (and sample preparation) eleven fusion discs and pellets of a laboratory standard were also analyzed. The mean, standard deviation and coefficient of variation for each element and oxide determination could then be calculated for a particular run.

Appendix D: Analytical Results

Table 44. Major oxide analyses, Anderson Lake Inlier, Wollaston Domain

Dept. No. 7508-	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	H_2O^-	LOI	Total
0284	70.50	0.29	13.60	1.33	2.00	0.05	1.19	0.65	4.11	4.77	0.05	1.22	0.31	100.07
0285	70.09	0.41	13.65	3.74	0.04	0.07	1.54	1.11	3.37	5.05	0.09	0.34	0.31	99.81
0286	72.74	0.20	13.81	1.03	0.90	0.03	0.95	0.78	4.26	4.42	0.05	0.22	0.27	99.66
0287	71.42	0.27	14.37	0.94	1.56	0.04	1.44	0.75	4.22	4.24	0.06	0.15	0.63	100.10
0288	68.57	0.45	14.56	1.58	2.51	0.09	1.19	1.61	4.86	4.35	0.09	0.13	0.13	100.11
0318	72.45	0.29	12.97	1.08	1.58	0.06	1.03	0.87	3.84	5.30	0.04	0.04	0.11	9.67

Table 45. Trace element analyses, Anderson Lake Inlier, Wollaston Domain

Dept. No. 7508-	Nb	Zr	Y	Sr	Rb	V	U
0284	20	312	43	76	165	19	1.9
0285	18	426	42	125	153	19	0.6
0286	19	224	47	90	175	11	1.9
0287	16	270	28	69	155	11	0.4
0288	19	470	58	148	145	13	1.8
0318	20	351	67	67	158	0	1.2
Average granite[1]	20	180	40	285	150	20	4.8
Average granodiorite	20	140	30	450	120	100	3.0

[1]from Taylor (1966)

Table 46. CIPW norms, Anderson Lake Inlier, Wollaston Domain

	CIPW Norm													
Dept. No. 7508-	Q	Or	Ab	An	Opx	Cpx	Mt	Ilm	Co	Ap	H_2O	Total	Differentiation Index	Normative Plagioclase: amount (composition)
0284	24.32	28.19	34.78	2.90	5.15	-	1.93	0.53	0.61	0.12	1.53	100.08	87.28	37.68 (An_8)
0285	26.96	29.84	28.52	3.92	3.84	-	-	0.23	1.20	0.21	0.65	99.81	85.32	32.44 (An_{12})
0286	27.86	26.12	36.05	3.54	2.89	-	1.49	0.38	0.72	0.12	0.49	99.66	90.03	39.59 (An_9)
0287	26.28	25.06	35.71	3.33	5.30	-	1.36	0.51	1.62	0.14	0.78	100.09	87.05	39.04 (An_9)
0288	17.95	25.71	41.12	5.07	4.74	1.92	2.29	0.85	-	0.21	0.26	100.12	84.77	46.19 (An_{11})
0318	26.13	31.32	32.49	2.50	3.59	1.27	1.57	0.55	-	0.09	0.15	99.66	89.94	34.99 (An_7)

Table 47. Major oxide analyses, Wathaman Batholith, Rottenstone Domain

Dept. No. 7508-	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	H_2O^-	LOI	Total
0296	69.40	0.25	15.17	0.89	1.01	0.03	1.20	1.66	4.32	4.78	0.11	0.06	0.32	99.19
0297	70.04	0.31	15.08	0.87	1.45	0.04	1.38	2.00	5.42	2.73	0.10	0.06	0.22	99.69
0298	71.09	0.15	15.23	0.35	0.92	0.03	1.15	1.61	4.57	4.16	0.05	0.29	0.35	99.94
0299	70.00	0.19	15.52	0.77	0.75	0.03	1.19	1.71	4.36	4.77	0.06	0.08	0.29	99.73
0299[1]	70.36	0.19	15.65	0.68	0.89	0.03	1.25	1.77	4.28	4.67	0.09	0.11	0.19	100.16
0300	68.45	0.35	15.50	0.98	1.55	0.03	1.49	2.04	4.65	3.79	0.14	0.04	0.62	99.63
0301	69.71	0.32	16.00	0.62	1.26	0.03	1.08	1.53	4.23	4.74	0.10	0.06	0.40	100.08
0302	70.54	0.27	15.36	0.38	1.40	0.03	1.07	1.54	4.19	4.55	0.10	0.09	0.54	100.05

[1]second sample

Table 48. Trace element analyses, Wathaman Batholith, Rottenstone Domain

Dept. No. 7508-	Nb	Zr	Y	Sr	Rb	V	U
0296	8.9	96	5.8	425	84	53	<0.2
0297	10	102	4.9	297	51	47	<0.2
0298	5.8	66	<2	501	60	40	<0.2
0299	4.5	120	<2	585	100	51	<0.2
0299[1]	4.8	130	<2	602	96	37	<0.2
0300	9.4	216	3.3	403	78	34	0.2
0301	7.7	192	<2	440	95	25	0.5
0302	10	148	5.4	341	100	33	0.3

[1]second sample

Table 49. CIPW norms, Wathaman Batholith, Rottenstone Domain

	CIPW Norm													
Dept. No. 7508-	Q	Or	Ab	An	Opx	Cpx	Mt	Ilm	Co	Ap	H_2O	Total	Differentiation Index	Normative Plagioclase: amount (composition)
0296	20.64	28.25	36.55	7.52	3.75	-	1.29	0.47	0.13	0.25	0.38	99.24	85.44	44.07 (An_{17})
0297	21.43	16.13	45.86	8.76	4.74	0.41	1.26	0.59	-	0.23	0.28	99.70	83.43	54.62 (An_{16})
0298	23.01	24.56	38.67	7.66	4.07	-	0.51	0.28	0.40	0.12	0.64	99.95	86.27	46.33 (An_{17})
0299	20.95	28.19	36.89	7.96	3.45	-	1.12	0.36	0.27	0.19	0.37	99.74	86.03	44.85 (An_{18})
0299[1]	21.82	27.60	36.22	8.19	3.93	-	0.99	0.36	0.55	0.21	0.30	100.16	85.63	44.41 (An_{18})
0300	25.24	22.40	39.35	9.21	5.23	-	1.42	0.66	0.37	0.32	0.66	99.63	86.99	48.56 (An_{19})
0301	21.75	28.01	35.79	6.94	4.02	-	0.90	0.61	1.37	0.23	0.46	100.08	85.56	42.73 (An_{16})
0302	23.29	26.89	35.45	6.99	4.53	-	0.55	0.51	0.98	0.23	0.53	99.96	85.63	42.44 (An_{16})

[1]second sample

Table 50. Major oxide analyses, Hickson Lake Batholith, La Ronge Domain

Dept. No. 7508-	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	H_2O-	LOI	Total
0289	71.88	0.23	14.89	0.36	1.10	0.03	1.16	1.69	4.93	3.08	0.05	0.10	0.44	99.95
0290	71.07	0.22	14.74	0.02	1.39	0.03	1.03	1.40	4.42	4.16	0.11	0.03	0.33	98.96
0291	68.86	0.29	15.93	0.41	1.22	0.03	1.31	2.27	5.53	2.61	0.11	0.11	0.35	99.03
0292	68.10	0.43	16.44	0.38	1.90	0.04	1.51	2.79	5.86	1.41	0.14	0.03	0.28	99.31
0292[1]	67.92	0.42	16.50	0.34	1.83	0.04	1.40	2.76	5.71	1.51	0.15	0.08	0.29	98.94
0293	68.80	0.34	16.57	0.05	1.72	0.03	1.35	2.50	5.70	2.19	0.10	0.09	0.39	99.83
0294	72.61	0.08	14.57	0.31	0.47	0.02	0.94	0.95	4.51	4.59	0.05	0.03	0.23	99.35
0295	72.87	0.14	14.22	0.19	0.90	0.02	0.97	1.09	4.21	4.56	0.08	0.05	0.32	99.62

[1]second sample

Table 51. Trace element analyses, Hickson Lake Batholith, La Ronge Domain

Dept. No. 7508-	Nb	Zr	Y	Sr	Rb	V	U
0289	8.8	99	2	424	79	34	0.2
0290	8.5	143	3.0	344	100	29	0.8
0291	5.6	107	2	867	64	42	0.5
0292	8.4	145	2	665	73	36	0.4
0292[1]	9.1	144	2.9	680	73	44	0.5
0293	0.9	143	2	1059	44	37	0.2
0294	13	53	16	152	139	27	2.4
0295	12	108	7.4	176	159	32	0.7

[1]second sample

Table 52. CIPW norms, Hickson Lake Batholith, La Ronge Domain

Dept. No. 7508-	CIPW Norm												Differentiation Index	Normative Plagioclase: amount (composition)
	Q	Or	Ab	An	Opx	Cpx	Mt	Ilm	Co	Ap	H_2O	Total		
0289	25.57	18.20	41.72	8.06	4.29	-	0.52	0.44	0.49	0.12	0.54	99.94	85.49	49.78 (An_{16})
0290	24.20	24.58	37.40	6.23	4.79	-	0.03	0.42	0.68	0.25	0.36	98.95	86.18	43.63 (An_{14})
0291	19.53	15.42	46.79	10.54	4.74	-	0.59	0.55	0.14	0.25	0.46	99.03	81.74	57.33 (An_{19})
0292	19.63	8.33	49.59	12.93	6.30	-	0.55	0.82	0.54	0.32	0.31	99.31	77.55	62.52 (An_{21})
0292[1]	20.23	8.92	48.32	12.71	5.95	-	0.49	0.80	0.81	0.35	0.37	98.95	77.47	61.03 (An_{21})
0293	18.99	12.94	48.23	11.75	5.97	-	0.07	0.65	0.52	0.23	0.48	99.83	80.16	59.98 (An_{20})
0294	25.28	27.12	38.16	4.39	2.85	-	0.45	0.15	0.58	0.12	0.26	99.36	90.57	42.55 (An_{10})
0295	26.78	26.95	35.62	4.88	3.72	-	0.28	0.27	0.57	0.19	0.37	99.62	89.35	40.50 (An_{12})

[1]second sample

Table 53. Major oxide analyses, supracrustal rocks from the Wollaston (0283), Rottenstone (0062) and La Ronge (0269, 0274) Domains

Dept. No. 7508-	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	H_2O-	LOI	Total
0062	53.52	0.85	17.15	2.11	6.73	0.11	3.64	9.35	0.96	1.44	0.38	0.40	3.09	99.73
0269	46.34	1.29	14.30	0.68	10.22	0.26	7.00	13.73	1.55	1.56	0.17	0.27	2.17	99.55
0274	67.11	0.40	12.43	3.24	0.46	0.04	1.63	1.36	3.12	3.02	0.07	0.36	6.58	99.81
0283	79.55	0.11	8.40	0.19	1.64	0.20	1.82	1.77	0.91	4.34	0.03	0.10	0.77	99.83

Table 54. Trace element analyses, supracrustal rocks from the Wollaston (0283), Rottenstone (0062) and La Ronge (0269, 0274) Domains

Dept. No. 7508-	Nb	Zr	Y	Sr	Rb	V	U
0062	12	122	25	419	45	206	1.5
0269	9.3	83	34	283	86	354	0.3
0274	14	166	29	205	76	119	3.1
0283	13	135	14	70	159	21	0.2

Appendix E: Metamorphic Mineral Assemblages

Wollaston Domain

Archean basement granite:

	hornblende	+	quartz	+	plagioclase	+	microcline	(with intense ribbon perthite)
biotite	+ hornblende	+	quartz	+	plagioclase	+	microcline	(with intense ribbon perthite)
biotite	+		quartz	+	plagioclase	+	microcline	(with intense ribbon perthite)

Aphebian metasediments:

biotite	+ muscovite	+ cordierite	+	sillimanite[1]	+ quartz	+	microcline		(Unit 2)
biotite	+	cordierite	+	sillimanite[1]	+ quartz	+	microcline		(Unit 4)
biotite	+	garnet	+		quartz	+	microcline	+ plagioclase	(Unit 2)
biotite	+	garnet	+		quartz	+		plagioclase	(Unit 2)
biotite	+ muscovite	+		sillimanite	+ quartz	+	microcline	+ plagioclase	(Unit 2)
biotite	+ muscovite	+			quartz	+		plagioclase	(Units 2,3)
biotite	+ muscovite	+		sillimanite	+		microcline	+ plagioclase	(Unit 2)
	muscovite	+		sillimanite	+ quartz	+		plagioclase	(Unit 2)
	muscovite	+ graphite	+		quartz	+	microcline		(Unit 3)
biotite	+ muscovite	+			quartz				(Unit 3)
biotite	+ muscovite	+ graphite	+		quartz	+	microcline	+ plagioclase	(Units 2,3)
biotite	+				quartz	+	microcline	+ plagioclase	(Units 2,4)
biotite	+ muscovite	+			quartz	+	microcline	+ plagioclase	(Unit 5)
biotite	+	hornblende	+		quartz	+	microcline	+ plagioclase	(Unit 2)
		tremolite	+		quartz	+	microcline	+ plagioclase	(Unit 5)
biotite	+	tremolite	+		quartz	+	microcline	+ plagioclase	(Unit 5)
biotite	+ diopside	+ tremolite	+		quartz	+	microcline	+ plagioclase	(Unit 2)
biotite	+ diopside	+ tremolite	+	garnet	+ quartz	+	microcline		(Unit 2)
biotite	+ diopside	+ tremolite	+	scapolite	+ quartz	+	microcline	+ plagioclase	(Unit 6)
	diopside	+		carbonate	+ quartz				(Unit 6)
		tremolite	+	carbonate	+ quartz				(Unit 6)
biotite	+	tremolite	+	scapolite	+ quartz	+	microcline	+ plagioclase	(Unit 6)
		tremolite	+		quartz	+		plagioclase	(Unit 6)

Rottenstone Domain

Distinctive metamorphic mineral assemblages have formed only within the paleosome of the migmatitic gneisses:

biotite	+					quartz	+ plagioclase	
biotite	+					quartz	+ plagioclase	+ microcline
biotite	+ sillimanite	+ garnet	+			quartz	+ plagioclase	
biotite	+	garnet	+			quartz	+ plagioclase	
biotite	+ sillimanite	+ garnet	+			quartz	+ plagioclase	+ microcline
biotite	+			actinolite	+	quartz	+ plagioclase	
biotite	+			hornblende	+		plagioclase	
biotite	+	garnet	+	hornblende	+ quartz	+	plagioclase	
biotite	+			actinolite	+ quartz	+	plagioclase	+ microcline
				hornblende	+ quartz	+	plagioclase	
				hornblende	+		plagioclase	
biotite	+			hornblende	+ quartz	+	plagioclase	
biotite	+		diopside	+ hornblende	+		plagioclase	
			diopside	+ hornblende	+ quartz	+	plagioclase	
			diopside	+ actinolite	+		plagioclase	

La Ronge Domain

biotite +		quartz + plagioclase		(Unit 10)
biotite + muscovite +		quartz + plagioclase + microcline		(Units 10,18)
biotite + actinolite +		quartz + plagioclase		(Unit 10)
hornblende +		plagioclase		(Unit 10)
biotite + actinolite +	garnet +	quartz + plagioclase		(Unit 10)
biotite +		quartz + plagioclase + microcline		(Unit 18)
biotite + sillimanite +		quartz + plagioclase		(Unit 18)
biotite + muscovite +	opaques +	quartz		(Unit 18)
biotite + muscovite +		quartz + plagioclase		(Unit 18)
biotite + graphite +	opaques +	quartz + plagioclase		(Unit 18)
biotite + actinolite +	opaques +	quartz + plagioclase + microcline		(Unit 18)
actinolite +	opaques +	quartz + plagioclase + microcline		(Unit 18)
biotite + hornblende +	opaques +	plagioclase		(Unit 18)
biotite + hornblende +		quartz + plagioclase + microcline		(Unit 18)